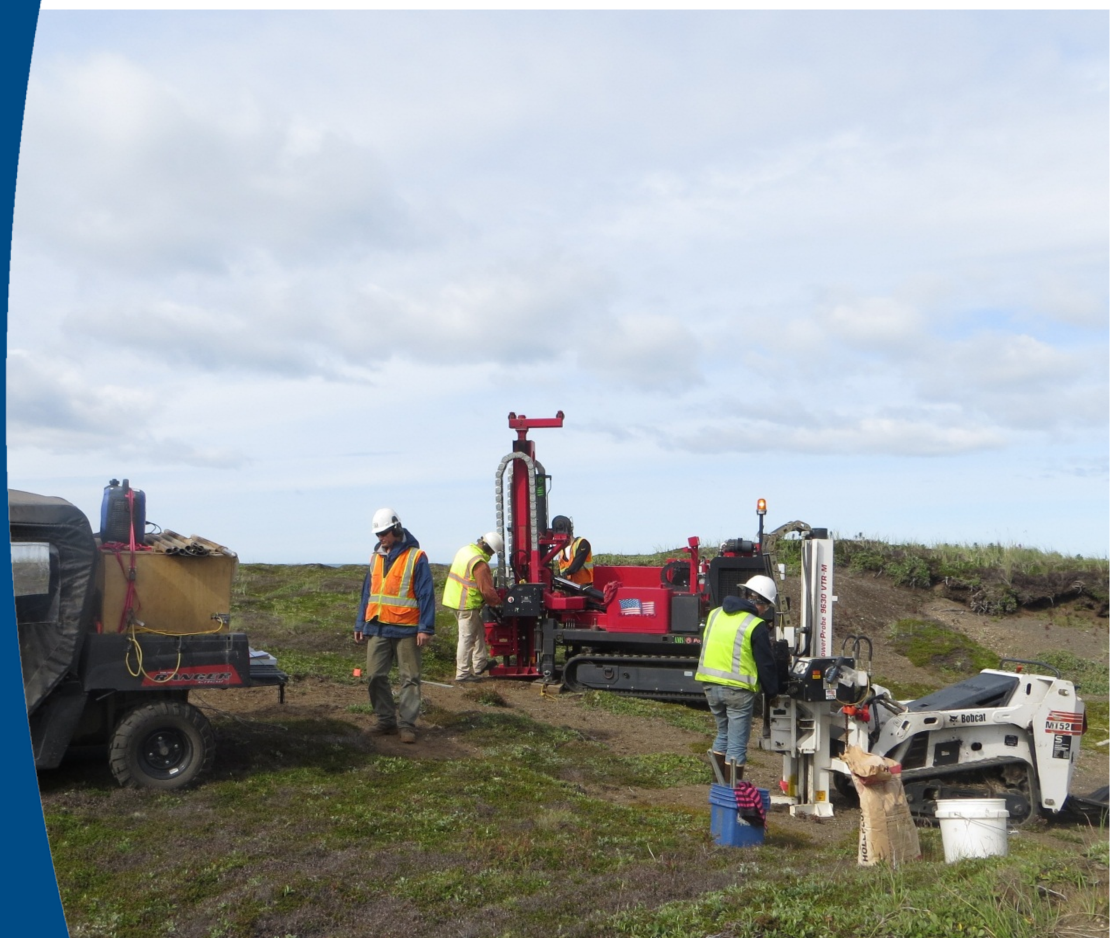
VOLUME I

Final
Remedial Investigation Report
Fort Morrow Remedial Investigation
Port Heiden, Alaska



Prepared for:
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Contract No. W911KB-11-D-0006, Delivery Order No. 0004

Prepared for:
U.S. Army Corps of Engineers, Alaska District
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EXECUTIVE SUMMARY

In June through October, 2012, North Wind, Inc. (North Wind) conducted a Remedial Investigation (RI) at the Former Fort Morrow Army Post, located at Port Heiden, Alaska. The project was conducted under Contract No. W911KB-11-D-0006, Delivery Order # 0004 for the United States Army Corps of Engineers (USACE), Alaska District.

The RI at the former Fort Morrow is being conducted in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the maximum extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. Petroleum, oil, and lubricant (POL)-contaminated sites fall under the CERCLA petroleum exclusion and are therefore being addressed under the authority of the Defense Environmental Restoration Program (DERP), United States Code, Title 10, Section 2701, et seq. The DERP provides authority to cleanup petroleum contamination when it may pose an imminent and substantial endangerment to public health, welfare, or the environment. For this effort, USACE accepts that the Alaska Department of Environmental Conservation (ADEC) Site Cleanup Rules (18 AAC 75, Article 3, Oil and Other Hazardous Substances Pollution Control) since they are risk based and indicative of when an imminent and substantial endangerment to the public health or welfare or the environment is present.

The purpose of the RI is defined by the data quality objectives. The objectives of the investigation were to:

- Assess the presence or absence of contaminated surface and subsurface soils, surface water, if present, and groundwater.
- Where present, assess the nature and extent of surface and subsurface soil contamination and groundwater contamination.
- Collect sufficient data to develop an ecological and human health conceptual site model (CSM) to evaluate potential exposure pathways and assess risk.

The Fort Morrow site was occupied by the U.S. Army between 1942 and 1945 to support the war effort in the Aleutian Islands. Supplies used as part of this effort included thousands of drums of aviation fuel, POLs, and other maintenance fluids. The amount of these materials released to the environment is not accurately known. Previous limited investigations have indicated that contaminated soils are present which prompted further investigation. The former Fort Morrow is identified in the ADEC Contaminated Sites Database as Hazard ID 73.

During the planning phase for the RI, the Fort Morrow site was divided into 13 Areas of Concern (AOCs). Using historical information and aerial photography, the site features to be investigated and associated chemicals of potential concern (COPCs) were identified for each AOC during the scoping meetings held with the Port Heiden Triad Team. The COPCs included POLs, polychlorinated biphenyls (PCBs), metals, and a range of volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs). Field investigation began with soil screening techniques including Ultraviolet Optical Screening Tool (UVOST) and ultraviolet (UV) fluorescence test kits for POLs, x-ray fluorescence (XRF) for metals and an alpha and gamma radiation detector for radionuclides. The field screening results from the UVOST were used to identify sampling locations for laboratory analysis of gasoline range organics (GRO), diesel range organics (DRO), and residual range organics (RRO). Collection of samples for laboratory analysis of VOCs, SVOCs, pesticides and dioxins was also identified for some of the site features. The combination of soil screening and laboratory analytical results were then used following a specific decision tree flow chart to determine if groundwater, surface water and sediment samples needed to be collected to delineate the full extent of contamination present in any of the AOCs.

At the 10 AOCs investigated in 2012, 187 site features were screened with the UVOST system. Over 1,350 UVOST screening boreholes were drilled in those 10 AOCs, with nearly 4 miles drilled. Of the 1,350 boreholes screened, only 18 site features showed evidence of POL contamination to be present. Only 6 of these 18 features were confirmed by sampling to have contamination present above the project action levels (PALs). The PALs are the risk based criteria for residential exposure, promulgated by the State of Alaska or calculated using the same algorithms used for the promulgated PALs. PALs were either taken from ADEC regulations or from the June 2012 U.S. Environmental Protection Agency (EPA) Residential Screening Levels (RSLs) if values were not available from the ADEC regulations.

Based on the UVOST screening data and analytical results, the estimated volume of POL soil above the PALs in AOC C is 832 cubic yards, in AOC D is 256 cubic yards, in AOC F is 43 cubic yards, and in AOC J is 310 cubic yards.

Radiological screening was conducted at one site feature, C-XR-001. No radiological contamination above background was detected.

One hundred fifty-two soil samples were collected for full suite analysis (POL, PCBs, metals, VOCs, and SVOCs) – 36 for POL analysis, 103 for PCB analysis, 5 for metals analysis, and 6 for VOC suite analysis in the 10 AOCs. Results of the soil samples analyzed by the project laboratory indicate that there is subsurface contamination above the PALs at 19 site features in six of the 10 AOCs investigated in 2012. The AOCs with PAL exceedances include C, D, E, F, H, and J. The concentration range of COPCs detected above project action levels in the six AOCs include:

- DRO at 1,500 to 21,000 mg/kg (PAL = 250 mg/kg),
- RRO at 12,000 to 14,000 mg/kg (PAL = 10,000 mg/kg),
- Arsenic at 8 to 28 mg/kg (PAL = 7.05 mg/kg),
- Total chromium at 250 mg/kg (PAL = 25 mg/kg),
- Lead at 4,300 mg/kg (PAL = 400 mg/kg),
- Methyl tert-butyl ether (MTBE) at 1.6 to 7.7 mg/kg (PAL = 1.3 mg/kg),
- Bromomethane at 0.3 mg/kg (PAL = 0.16 mg/kg), and
- 2-methylnaphthalene at 18 mg/kg (PAL= 6.1 mg/kg).

PCB and GRO contamination were not detected above PALs in any of the 10 AOCs. It is likely that the arsenic, chromium, and manganese detections are naturally occurring and are not from anthropogenic sources. Methylene chloride is a suspected laboratory contaminant. MTBE was not used as a fuel additive during the period of occupancy for Fort Morrow.

In accordance with ADEC regulations, surface water or sediment samples were not collected as no surface water bodies were found to be closely connected to petroleum contaminated groundwater. The only groundwater found to contain contaminants at levels above the PALs was near site feature C-LT-002.

It was determined that there were no bodies of water that met the approved Work Plan definition of a significant water body of more than 100 square feet located within 50-feet downgradient of this area.

Eighteen groundwater monitoring wells were installed and sampled and 12 piezometers were installed to measure groundwater elevation and to calculate the groundwater flow direction.

The results of the groundwater sampling indicate that contamination above PALs is present in four wells located in three AOCs:

- Monitoring well C-MW-001 in AOC C had a DRO exceedance of 3,500 µg/L (PAL=1,500 µg/L), and manganese at 750 µg/L (PAL = 320 µg/L).
- Monitoring well F-MW-001 in AOC F had a manganese exceedance of 350 µg/L.
- Monitoring well J-MW-002 in AOC J had a cobalt exceedance at 6.7 µg/L (PAL= 4.7 µg/L), iron at 18,000 µg/L (PAL= 11,000 µg/L) and manganese at 370 µg/L.
- Monitoring well J-MW-003 in AOC J had an arsenic exceedance at 11 µg/L (PAL = 10 µg/L), cobalt at 12 µg/L, iron at 46,000 µg/L, lead at 24 µg/L (PAL= 15 µg/L) and manganese at 420 µg/L.

The metals detected above the PALs are believed to be naturally occurring in the former Fort Morrow area in subsurface soil.

A geophysical investigation was performed at 17 site features in AOCs B, C, D, E and F. Of the 17 site features screened, anomalies detected and interpreted to be buried metal were found at seven site features:

- B-DS-001,
- B-MH-001,
- B-QT-043,
- B-LT-001,
- C-DB-001,
- E-DS-001, and
- F-DS-001.

Due to the likely presence of the buried debris, these site features were not screened or sampled.

A correlation study was completed for two types of COPCs; metals (including lead and arsenic) and DRO. Metals were not detected in surface soils at high enough concentrations to yield a meaningful correlation. Almost all the XRF readings were below the level of detection (LOD), in addition many metals were not detected in the laboratory samples. Thirty-six soil samples were collected for the DRO correlation study analysis. Screening with the UVOST system and SiteLAB® test kits was compared to analytical laboratory results. The UVOST system laser induced fluorescence (LIF) was calibrated to the standard reference emitter (RE) before each measurement. A linear regression comparing the POL concentration derived from laboratory analysis was compared to the direct UVOST measurement of that same soil sample. The UVOST measurements were made in *exsitu* or emulation mode. The relationship between the concentration of POL and LIF was found to be nearly linear for concentrations near the PALs. It was observed that measurements of approximately 1 %RE higher than the background measurement was indicative of POL laboratory concentrations above the PALs when measured *exsitu*.

Down borehole measurements of the same soil before removal from the ground showed that the *insitu* measurements of the soil was slightly higher than when measured exsitu. High concentrations of fuels several magnitudes above the PALs, especially those fuels with high levels of residual range organics (RRO) appear to exhibit lower levels of %RE than a straight line correlation would have predicted. These higher values correlate much better when modeled with a polynomial trend line. This type of correlation trend is common with UVOST when measuring longer chained polycyclic aromatic hydrocarbon fuels that exhibit energy transfer and fluorescence quenching.

The off-site analytical data were validated for data usability and limitations by the third-party data validators in accordance with the project Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Work Plan. Practically 100% of the data were found to be acceptable and usable as reported and qualified. Less than 0.1% of the data were deemed not usable and were rejected. Overall, the accuracy of the analytical data for the project is deemed acceptable.

A cumulative risk evaluation was performed using the results of the soil and groundwater sample analyses. There are no risk-contributing or petroleum hydrocarbon COPCs in AOCs G, H, I, K, and L. Therefore, no further action is necessary for the soil in AOCs G, H, I, K, and L.

Arsenic is the sole contributor to risk in AOC E and is believed to be naturally occurring. There are no petroleum hydrocarbon COPCs in AOC E, therefore, no further action is necessary for the soil in AOC E.

If the specific areas of petroleum hydrocarbon contamination were remediated to meet PALs, the cumulative risk would allow for cleanup complete status with no restrictions for the remaining AOCs: C, D, F, and J.

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ACRONYMS AND ABBREVIATIONS

AA	alternative action
AAC	Alaska Administrative Code
ADEC	Alaska Department of Environmental Conservation
AGC	Army Geospatial Center
amsl	above mean sea level
AOC	Area of Concern
AST	aboveground storage tank
ASTM	American Society of Testing and Materials
AVGAS	aviation gasoline
bgs	below ground surface
BP	before present
BTEX	benzene, toluene, ethylbenzene, and xylenes
BTOC	below top of casing
BU	building unknown
°C	degrees Celsius
CD	compact disc
CDQR	Chemical Data Quality Report
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CO_2	carbon dioxide
COC	contaminant of concern
COPC	chemical of potential concern
CORS	continuously operating reference station
CSD	coordinate system database
CSM	conceptual site model
DERP	Defense Environmental Restoration Program
DO	dissolved oxygen
DOT	Department of Transportation

DRO	diesel range organics
DVD	digital video disc
EPA	U.S. Environmental Protection Agency
ERBSC	Ecological Risk-based Screening Concentration
°F	degrees Fahrenheit
FS	Feasibility Study
FUDS	Formerly Used Defense Site
GAC	granulated activated carbon
GIS	Geographical Information System
GPS	global positioning system
GRO	gasoline range organics
GTA	GeoTek, Alaska
HCl	hydrochloric acid
HI	hazard index
HNO_3	nitric acid
HTRW	hazardous, toxic, and radiological waste
ID	identification
IDW	investigation derived waste
IRIS	Integrated Risk Information System
LCS	laboratory control sample
LCSD	laboratory control sample duplicate
LIF	laser induced fluorescence
LNAPL	light non-aqueous phase liquid
LOD	limit of detection
MED	Manual for Electronic Deliverables
mg/kg	milligrams per kilogram
mg/L	milligrams per liter
mL	milliliter

MMRP	Military Munitions Response Program
MOGAS	motor gasoline
MS/MSD	matrix spike/matrix spike duplicate
MTBE	methyl tert-butyl ether
NAPL	non-aqueous phase liquid
nm	nanometer
North Wind	North Wind, Inc.
NTU	nephelometric turbidity unit
OPUS	Online Positioning User Service
ORP	oxidation reduction potential
OST	optical screening tool
PAH	polycyclic aromatic hydrocarbon
PAL	project action level
PARCCS	precision, accuracy, representativeness, comparability, completeness and sensitivity
PCB	polychlorinated biphenyl
POL	petroleum, oil, and lubricant
PPE	personal protective equipment
ppm	parts per million
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
QC	quality control
QSM	Quality Systems Manual
RBC	risk-based concentration
RCRA	Resource Conservation and Recovery Act
RE	reference emitter

RGB	red/green/blue
RI	remedial investigation
RI/FS	remedial investigation/feasibility study
RPD	relative percent difference
RRO	residual range organics
RRS	Radio Relay Station
RSD	relative standard deviation
RSL	regional screening level
SOP	Standard Operating Procedure
SPOC	shock protected optical casing
SVOC	semivolatile organic compound
TAL	Test America Laboratories
TOC	top of casing
TSCA	Toxic Substances Control Act
UFP-QAPP	Uniform Federal Policy for Quality Assurance Project Plans
µg/L	micrograms per liter
UN	unknown
USACE	United States Army Corps of Engineers
USAF	United States Air Force
USAGC	U.S. Army Geospatial Center
UST	underground storage tank
UTL	upper tolerance limit
UV	ultraviolet
UVOST	Ultra Violet Optical Screening Tool
VOA	volatile organic analysis
VOC	volatile organic compound
XRF	x-ray fluorescence

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1. INTRODUCTION

The United States Army Corps of Engineers (USACE) tasked North Wind, Inc. (North Wind) with conducting a Remedial Investigation (RI) for portions of the former World War II era Fort Morrow Army Post under Contract No. W911KB-11-D-0006, Delivery Order # 0004. This RI report presents the results of the investigation and includes an evaluation of the nature and extent of identified areas of contamination.

This report is organized as follows:

- Section 1 describes the purpose of the report and summarizes historic information known regarding the former Fort Morrow.
- Section 2 describes the physical characteristics of the former Army Post, including climate, topography, geology, and hydrogeology.
- Section 3 describes the field investigation methodology, including field screening, geophysical surveying soil borehole sampling and logging procedures, monitoring well installation and development, groundwater sampling procedures, and global positioning system (GPS) and professional surveying methods.
- Section 4 describes the nature and extent of the contamination identified at the site, presents the laboratory data results, and summarizes the findings.
- Section 5 provides a discussion of the results of the data evaluation and validation.
- Section 6 describes the summary of the results of the investigation in the 10 Areas of Concern (AOCs) investigated in 2012; AOC C through AOC L.
- Section 7 provides a listing of reference documents used in the generation of this report.

The detected soil and groundwater results above project action limits are included in Appendix A. All soil and groundwater sample results are included in Appendix B.

1.1 Purpose and Objectives

1.1.1 Purpose

The overall purpose of this RI was to determine:

- What areas of the former Fort Morrow have been impacted by Army operations?

- Does environmental contamination at areas or specific features of the former Fort Morrow exceed the project action levels (PALs) established by 18 Alaska Administrative Code (AAC) 75 Method 2 tables, and the June 2012 U.S. Environmental Protection Agency (EPA) residential screening levels (RSLs) if values were not available from the ADEC regulations?

- What is the nature, areal extent and maximum concentration levels of contamination at any areas or site features that exceed the applicable PALs?

- Does the contamination that may exceed PALs pose unacceptable risks to receptors identified in the Conceptual Site Model (CSM)?

1.1.2 Objective

The objective of this RI is to gather sufficient data to ultimately determine the possible alternative actions (AAs) for each of the project AOCs. Physical, geotechnical, and chemical screening of identified site features, as well as the analytical data, were collected and will be evaluated following this RI report to determine decision conditions. The following AAs are considered based on the specific potential hazards present in any given AOC:

- No further action at any given site feature if screening and confirmation sampling indicates that contamination is not present above regulatory levels,

- Possible interim removal/remedial action if specific health based risks are identified,

- Include in a removal/remedial action through the remedial investigation/feasibility study (RI/FS) process, and

- Collect additional data in order to possibly perform a risk based evaluation of the feature.

The selection of one of the AAs for a specific site feature or decision unit and potential hazard may be based on the criteria presented below. The final selection will be made jointly by USACE and the Alaska Department of Environmental Conservation (ADEC).

No Further Action. This option may be selected when the RI indicates that a particular decision unit presents no apparent risk to human health or to the environment. Results of sampling and analysis of environmental media from the suspected area of highest potential contamination should show that no contamination is present or that existing contaminant concentrations are below the PALs.

Initiate Interim Removal Action. When the results of a limited field investigation confirm that a chemical release has occurred and the environmental contamination exceeds threshold concentrations, initiation of an interim removal action may be recommended. A removal response is appropriate only when site specific conditions indicate an imminent threat to human health, safety, or the environment.

Inclusion in the RI/FS removal/remedial action design. If the results of the field investigation confirm that a chemical release has occurred and that environmental contamination exceeds the PALs, the source area will be included in the RI/FS process, which will lead to a decision document and a remedial design/remedial action.

1.2 Regulatory Setting

1.2.1 Regulatory Requirements

The RI at the former Fort Morrow is being conducted in accordance with Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986, and to the maximum extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. Petroleum, oil, and lubricant (POL)-contaminated sites fall under the CERCLA petroleum exclusion and are therefore being addressed under the authority of the Defense Environmental Restoration Program (DERP), United States Code, Title 10, Section 2701, et seq. The DERP provides authority to cleanup petroleum contamination when it may pose an imminent and substantial endangerment to public health, welfare, or the environment. For this effort, USACE has agreed that the ADEC Site Cleanup Rules (18 AAC 75, Article 3, Oil and Other Hazardous Substances Pollution Control) are risk based and indicative of when an imminent and substantial endangerment to the public health or welfare or the environment has been mitigated. The former Fort Morrow is identified in the ADEC Contaminated Sites Database as Hazard ID 73.

Releases of fuels or other hazardous substances, their characterization, and remediation are regulated based on the point or depth of release as well as the media in which the contaminants are released or found. Surface releases are regulated under 18 AAC 75, Sub-Section 3. 18 AAC 78 is also applicable to this investigation where known underground storage tanks (USTs) existed, as it is possible that USTs exist(ed) at the Formerly Used Defense Site (FUDS) that comprises the Fort Morrow area or that drums containing petroleum or hazardous materials may have been buried. In situations where petroleum contaminated groundwater is closely connected hydrologically to nearby surface water, ADEC Water Quality Standards (ADEC, 2012) under 18 AAC 70 are applicable, as specified in 18 AAC 75.345. These water quality standards are dependent on the type of water (i.e., fresh water or marine water) and the use classification of the water body (i.e., water supply; water recreation; growth and propagation of fish, shellfish, -other aquatic life, and wildlife; and harvesting for consumption of raw mollusks or other raw aquatic life).

The RI and this RI report's evaluation of the data are based upon the use of the ADEC and EPA cleanup levels for soils contaminated with petroleum hydrocarbons or other chemicals as the PALs or screening levels at the former Fort Morrow site. The PALs are the risk based criteria for residential exposure, promulgated by the State of Alaska or calculated using the same algorithms used for the promulgated PALs. PALs were either taken from ADEC regulations or from the June 2012 EPA RSLs if values were not available from the ADEC regulations.

Arsenic concentrations within soil were compared to the site specific arsenic background concentration determined by the United States Air Force (USAF) during their RI at the Port Heiden Radio Relay Station (RRS) (USAF, 2006). The upper tolerance limit value of 7.05 mg/kg for subsurface soils was utilized as the PAL. The cleanup levels from Table C of 18 AAC 75 were used as the groundwater PALs for this investigation unless levels for a specific compound were not available, in which case the level was then taken from the June 2012 EPA RSLs for Chemical Contaminants at Superfund Sites screening level/preliminary remediation goals (PRGs) table adjusted to a carcinogenic risk level of 1×10^{-5} and a non-carcinogenic risk (hazard quotient) of 0.1. ADEC regulations require that the application of the specific cleanup levels for each chemical depends on whether the site is in an arctic zone, a non-arctic zone with annual precipitation of less than 40 inches, or a non-arctic zone with annual precipitation of greater than or equal to 40 inches. Additionally, within these categories there are three distinct cleanup levels, each based on one of three possible human exposure routes: ingestion, inhalation, or indirectly through migration from contaminated soil to groundwater.

The former Fort Morrow is located in a non-arctic zone with precipitation of less than 40 inches per year. Therefore, the soil cleanup values under this category are used as screening criteria for analytical data generated during this RI. The CSMs developed for each AOC indicate that all three Method Two exposure pathways exist at this site; therefore, the most stringent of the three pathway-specific cleanup levels (typically migration to groundwater) are employed for each site feature and AOC (ADEC, 2010a).

1.2.2 Receptors

The future land use of the former Fort Morrow facility is considered to be unrestricted residential use. Local residents are known to be subsistence harvesters (e.g., berries and vegetation) and subsistence consumers (e.g., fish, fowl, eggs, mammals, and clams). Metals, which may bioaccumulate, are present in the root zone and depth of burrowing animals in all AOCs. Therefore, in accordance with ADEC guidance, this pathway for current/future subsistence receptors is complete. The AOC specific discussions will differentiate where the risk is elevated due to the confirmed presence of high levels of these constituents.

It is possible that occupied buildings on the site, or which may be constructed on the site in the future, are in an area that could be affected by contaminant vapors (e.g., within 30 horizontal or vertical feet of petroleum contaminated soil or groundwater; within 100 feet of non-petroleum contaminated soil or groundwater).

Specific CSM release mechanisms and receptors for each of the individual AOCs will be included in the appropriate AOC portion of Section 4 of this report.

1.3 Background

Information on the background of the former Fort Morrow was presented in the Port Heiden/Fort Morrow Remedial Investigation Work Plan (North Wind, 2012). A general description is provided below.

1.3.1 Site Location

The former Fort Morrow is located in and around the present village of Port Heiden, Lake and Peninsula Burough County, Alaska. Port Heiden is located on the western side of the Alaska Peninsula near the Bering Sea and North Pacific Ocean.

1.3.2 Site Description

Approximately 8,000 acres of the Fort Morrow site were occupied by the U.S. Army between 1942 and 1945 to support the war effort in the Aleutian Islands. Logistical supplies for the support of the Aleutian campaign, as well as for the support of the nearly 5,000 airmen and soldiers stationed at Fort Morrow, were shipped to the area and then were stored on site. Thousands of drums of aviation fuel, POLs, and other maintenance fluids were stored at Fort Morrow in large drum caches. The amount of these materials released to the environment is not accurately known. Previous limited investigations have indicated that contaminated soils are present at the former Fort Morrow site, which prompted further investigation. The contamination previously identified has included POL, solvent, and polychlorinated biphenyl (PCB) contamination above regulatory levels.

For the sake of manageability, the site was divided into 13 AOCs – A through M (Figure 1-1). While each of these AOCs is based on a specific geographical area, attempts were made to group site features that were associated with a specific company, battalion, or special general type of land usage (e.g., hospital, warehouse, fueling area, airfield operations, etc.). AOCs C through L were field screened and sampled during the 2012 field season.

1.3.3 Site History

Fort Morrow was established during World War II to support operations against the Japanese in the Aleutian Islands. The Fort was activated June 17, 1942 and was placed in caretaker status on February 1, 1944. During its brief existence, Fort Morrow was staffed by a combination of U.S. Army Air Corps and U.S. Army units. The Air Corp units were located near the airfield with the Army units providing general defense and logistics support. The type of military unit and operation in any given area would ultimately determine the types of materials present and potentially the types of releases associated with each of the occupied areas.

Table 1-1 lists the units present at Fort Morrow. This listing was developed from information included in the "Bush Report" (Bush, 1944). The list of units was then compared to canceled postal mailing envelopes for A.P.O. 949 (Fort Morrow)[1]. A total of 54 cancelled envelopes were found for the year 1943. The individuals return address on the envelopes included the unit designation. All of the units listed in the "Bush Report" were verified to be present at Fort Morrow (the 260th Quartermaster Battalion Company D was replaced by the 201st Casual Quartermaster Company Detached by 1943). The only additional unit found by searching the postal history records was the 807th Engineer Battalion Detachment.

The location of individual units was also verified on a map entitled "Operations Map, Fort Morrow, Alaska" located in the National Archives of the U.S. Army Geospatial Center (USAGC) at College Park, MD (USAGC, 2010).

The specific history of use within each of the individual AOCs will be included in the appropriate portion of Section 4.

1.3.4 Previous Investigations and Remedial Actions

Review of previous site investigations and historical records has identified over 1,000 individual features that may require evaluation for environmental impacts. The geographic locations of these features and operational details were retrieved from the historical reports, site reconnaissance, and aerial photographs, and were recorded in a Geographical Information System (GIS) database by the USACE.

Twenty-four historical documents on the former Fort Morrow/Port Heiden, dated from 1976 through 2011, were extensively evaluated, relative to chemicals of potential concern (COPCs) in various affected media (i.e., surface soil, subsurface soil, surface water, and groundwater). The quality level of these documents varied widely from undated, unsourced, and poorly annotated site photographs to well-referenced site assessments and RI reports. Several of the documents were specific to the U.S. Air Force Port Heiden RRS and others contained information that was more relative to the Army occupied portions of the site.

Table 1-2 lists the 24 historical documents from previous remedial actions and investigations conducted at Fort Morrow. Additionally, a summary of the documents reviewed is provided in Appendix C.

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[1] Research of Postal History for Port Heiden, Alaska, http://www.postalhistory.com.

1.4 Project Mobilization/Demobilization

Mobilization of the North Wind field crew to Port Heiden occurred on Monday, June 18, 2012. Equipment was mobilized to the project site by Lynden Air Cargo L-100-30 Hercules aircraft. The field crew was transported by Security Aviation from Anchorage to Port Heiden. Overall, the field investigation portion of the project lasted for 4 months and 4 days.

Demobilization of the field crew out of Port Heiden occurred on Monday, October 22, 2012. Airlift of equipment was again handled by Lynden Air Cargo L-100-30 aircraft with the field crew transported by Security Aviation.

Several individual subcontractors were also involved in the execution of the RI. Dakota Technologies of Fargo, North Dakota provided on-site mentoring in the use of the Ultra Violet Optical Screening Tool (UVOST). GeoTek, Alaska from Anchorage, Alaska conducted the geophysical surveys and utility locates at the beginning of the field work. PDC Engineers, Inc. of Fairbanks, Alaska provided Alaska registered surveying of the location and elevation of the groundwater monitoring wells. URS Group, Inc. provided sampling personnel from its Anchorage and Seattle offices.

1.5 Key Personnel

The following key personnel are involved in the project and field execution:

Name	Title	Organizational Affiliation	Responsibilities
Ronald Pflum	Former Project Manager	USACE	Oversees project and responds to ADEC
Meseret Ghebreslassie	Current Project Manager/Lead Engineer	USACE	Oversees project and responds to ADEC Technical Lead
Lisa Geist	Environmental Engineering Supervisor	USACE	Contracting Officer's Representative (COR)
Amanda Whittier	Project Chemist	USACE	Chemistry oversight
Gordon Osgood	Engineer / Geographical Information System Specialist (GIS)	USACE	Reviews GIS deliverables, advises contractor GIS specialist, supports USACE technical lead
Neil Folcik	UVOST Support Team Lead	USACE	Lead USACE UVOST activities
Pat Roth	Project Manager	USAF, 611th Civil Engineer Squadron	Adjacent Site Project Manager
Louis Howard	Project Manager	ADEC	Regulatory oversight
Gerda Kosbruk	Administrator	Village of Port Heiden	Impacted local entity
Kim Kearney	Contractor Project Manager	North Wind	Manages project – coordinates between lead agency and subcontractors

Name	Title	Organizational Affiliation	Responsibilities
Kishor Gala	Senior Chemist/Contractor Data Validation	North Wind	Conducts oversight of laboratory and data validation subcontractors and is responsible for ensuring project data quality objectives are met.
Arden Bailey	Contractor Field Manager / Site Health and Safety Officer	North Wind	Supervises field sampling and coordinates all field activities. Certified UVOST Operator.
John Davis	UVOST Operator/ Field Sampler	North Wind	Collection of field screening and laboratory samples. Certified UVOST Operator.
Doug Larsen	UVOST Operator/ Field Sampler	North Wind	Collection of field screening and laboratory samples. Certified UVOST Operator.
Beth Norris	UVOST Operator/Field Data Manager	North Wind	Management and maintenance of collected field screening data. Can also assist with screening data and sample collection activities.
Kim Holmes	Field Sampler	URS	Collection of field screening and laboratory samples.
Dan McGauhey	Field Technician	North Wind	Packaging and shipping of samples under the supervision of an ADEC Qualified Sampler.
Shane Stoumbaugh	Push Probe Rig Operator/UVOST Operator	North Wind	Operation of direct push drill rigs. Certified UVOST Operator.
Deborah Smith	Data Validation Manager	Kestrel Environmental	Validation of laboratory data

2. PHYSICAL CHARACTERISTICS OF STUDY AREA

Geologic and climatological parameters have a dramatic effect on the fate and transport as well as the duration of any possible contaminants at the former Fort Morrow site. The following sections discuss the physical characteristics of the study area.

2.1 Climatological Conditions

Port Heiden has a maritime climate (Hartman and Johnson, 1984). Climatic conditions are affected by the Bering Sea and the North Pacific Ocean and are characterized by small temperature variations, high humidity, heavy precipitation, and frequent cloudy periods. Cyclonic storms with high winds, fog, and poor visibility occur frequently (Hartman and Johnson, 1984). Mountainous terrain of the Aleutian Range is about 10 km east of Port Heiden and provides protection from approaching southeasterly winds and precipitation. The mean annual temperature for the periods 1952 and 1987 for Port Heiden is 36.14 degrees Fahrenheit (°F). Mean monthly temperatures range from an August mean maximum of 57.92°F to a February mean minimum of 15.98°F (Leslie, 1989; Table 1). Mean annual precipitation is approximately 15.55 inches, and mean annual snowfall is approximately 51.57 inches. Mean monthly and annual temperature, precipitation, and snowfall for Port Heiden, Alaska (USGS, 1995) are summarized in Table 2-1.

2.2 Vegetation

Vegetation in the Port Heiden area consists of tundra, shrub tundra, and beach vegetation (Viereck and Little, 1972; NPS, 1987). Wet-tundra vegetation grows in lowlands on poorly drained organic-rich soils and is dominated by water-tolerant plants such as sphagnum. Moist-tundra vegetation grows on terraces, subalpine slopes, and coastal lowlands and consists of heaths, shrubs, and grasses. Alpine tundra vegetation is found on exposed slopes in upland areas and on the summits of ridges and knolls and consists of scattered heaths, lichens, and mosses. Shrub tundra is found on moderately well-drained lowlands and slopes below approximately 300 meters in elevation and consists of alder, willow, and grasses. Beach vegetation is found on well-drained coastal sand dunes and consists principally of ryegrass.

2.3 Geology, Soils, and Topography

Detterman et al. (1981a, b) have mapped the geology of the former Fort Morrow area. Major geologic units observed near the site of the former Fort Morrow include volcanic deposits, till, estuarine deposits, alluvial deposits, outwash deposits, swamp deposits, and marine terrace deposits. The volcanic deposits found in the Fort Morrow area consist of pumice, ash, debris-flow deposits, and ash-flow tuff of Holocene and Pleistocene age (Detterman et al., 198la). Figure 2-1 provides a geologic cross section through the project area.

The ash-flow tuff deposits were emplaced during the most recent caldera-forming eruption of Aniakchak Crater about 3,400 years before present (BP). The volcanic tuff is unsorted, poorly stratified, and mostly composed of pumice and scoria in a matrix of fine to coarse ash and lithic fragments (Detterman et al., 1981b). The ash-fall tuff is moderately well sorted, well stratified, and consists of fine- to medium-grained dacitic ash. Near the Port Heiden airfield, volcanic deposits are exposed on either side of the runway, around the radio beacon, on slopes adjacent to Reindeer Creek and Aniakchak Crater, and along the eastern shoreline of Hendrickson Lake. The depth to volcanic tuff deposits in other areas of the former Fort Morrow is not known specifically, but is likely between 75 and 150 feet below ground surface (bgs).

Debris-flow, pumice, and ash deposits were found near surface in much of the investigation area. Typically, these units non-conformably overlay a paleosol developed on earlier geologic deposits. The thickness of this most recent deposit stratigraphic sequence was found to vary from 2 to 20 feet where present. The underlying paleosol was typically highly florescent when penetrated with the UVOST probe. A thin tephra was present at the contact above the paleosol in several soil borings (see Figure 2-2).

Till deposits, a heterogeneous mixture of cobbles, gravel, sand, silt, and clay transported by glaciers, dominate the higher terrain in AOC K, AOC J, and the very southern portion of AOC L. Numerous arcuate moraine ridges are present, especially in the area surrounding the former Air Force RRS. The moraines consist of weathered, unsorted, and nonstratified glacial till and typically have an irregular knob and kettle surface topography. Boulders of up to 2 feet in diameter were found at the surface at several site features in AOC J. Hand augered boreholes in AOC L encountered large cobbles (4 inches in diameter) and occasional boulders at a depth of approximately 24 feet bgs. Boulders and very large cobbles were also found to armor the Bearing Sea beach in the southern portion of AOC K (see Figure 2-2).

Estuarine deposits found along the Bering Sea coast consist of dark-brown to black organic silt and clay. Swamp deposits are adjacent to the estuarine deposits south-southwest of the Port Heiden Airfield. These deposits form by the accumulation of sedge and sphagnum peat. A large alluvial fan, consisting mostly of well-sorted pumice, extends northwestward from the base of Aniakchak Crater toward the coast. These deposits extend to about 6.2 miles east of the airfield. Alluvial deposits also are found adjacent to Reindeer Creek near the northern edge of the former Fort Morrow. Outwash deposits found northwest of the airfield consist of moderately well-sorted and stratified sand, silt, and gravel that form a flat to gently sloping plain. Marine terrace deposits south of the airfield are typically about 40 feet above mean high tide. These deposits consist of stratified and well-sorted sand and gravel that form level plains truncated by steep wave-cut scarps (USGS, 1995).

The soils in the Fort Morrow area are generally poorly developed due to the geologically frequent deposition of volcanic ash (Rieger et al., 1979; Howard Grey and Associates, Inc., 1982). Where soils are well developed, they are dark brown to reddish brown and typically have buried surface horizons because of repeated deposition of volcanic ash. The soil particles are mostly sand or gravel size (Howard Grey and Associates, Inc., 1982). The Port Heiden area is generally free of permafrost (USGS, 1995).

Buried surface horizons, or paleosols, were present in many, if not most, UVOST and soil sampling boreholes. The paleosols were also very evident in the wave cut beach scarps along the Bearing Sea coast. UVOST boings showed elevated laser induced fluorescence (LIF) of 2 to 3 feet thick when penetrating the paleosols. Paleosols identified in sample boreholes were typically composed of fine-grained sand and silt with abundant organic material. However, the paleosol layer found in boreholes at the AOC J warehouse 003 (J-WH-003) site feature was composed entirely of organic material with very thin stringers of fine sand and silt. Florescence associated with this organic vegetation horizon at these locations was as high as 16% of the UVOST reference emitter (RE).

Non-anthropogenic mounded material was observed on the surface in several AOCs. These small mounds were typically circular in shape with a diameter of approximately 50 feet and were up to 8 feet in height. The mounded material was generally composed of fine sands and silts. These mounds differed from the anthropogenic mounded materials in that the naturally occurring mounds did not have evidence of tire tracks or bulldozing scars. It is likely that these features represent diapirs of the fine-grained sediments and paleosols being extruded upward under the weight of volcanic debris being deposited during the circa 3,400 year BP caldera forming eruption of Mount Aniakchak. The fine sands and silts in the underlying paleosol layer were found to be thixotropic in several cases. The material was occasionally observed to ooze upward in the borehole annular space during the drilling of UVOST boreholes. An examination of the eroding scarp at the beach in AOC K and AOC L showed areas of convoluted bedding in the underlying fine-grained materials in areas loaded by overlying volcanic ash and debris.

2.4 Hydrology and Groundwater Use

The principal groundwater aquifers near Port Heiden consist of 1) unconsolidated sand and gravel, 2) volcanic tuff (mostly pumice), and 3) bedrock. Silt- and clay-rich till layers locally act as confining beds (USGS, 1995). At the former Fort Morrow site, groundwater is present at relatively shallow depths ranging from 4 feet to approximately 60 feet. The deepest depths to groundwater are found near the RRS with the shallower depths being observed to the southeast and especially to the southwest areas of the Fort Morrow site. Most domestic drinking water wells in the area are completed to depths well below the local piezometric surface. The hydraulic head or elevation of groundwater in wells constructed well below the groundwater surface is nearly identical to wells constructed spanning the piezometric surface. This would tend to indicate that the aquifer is in general a continuous non-confined system. During the RI, it was noted that the surface elevation of local open water bodies closely matched the elevation of groundwater in wells located nearby.

Groundwater flow directions and gradients were computed by standard 3-point problem solutions for 19 sets of three wells. The resulting flow directions and gradients (Appendix D) are shown in Figures 2-3 and 2-4, respectively, and listed in Table 2-2.

Flow directions were generally toward the west or north with two exceptions:

1. Flow direction in AOC D was found to be steeply flowing toward the south southeast. However, it should be noted that of the three wells installed in AOC D, two encountered water at approximately 25 feet bgs while the third well did not encounter significant groundwater until nearly 50 feet bgs. It is likely that the shallower wells (the AOC D transformer 002 [D-TF-002] site feature) may have been completed in a perched local groundwater aquifer, while the deeper well (the AOC D dumpsite 001 [D-DS-001] site feature) may have been completed in the regional aquifer. The groundwater flow direction and groundwater gradient may not represent the true direction and gradient if the wells monitor different groundwater bodies.

2. Flow direction in the southern portion of AOC L, AOC K, and the northwestern portion of AOC J was found to be generally to the south. The gradient of flow in this area was also found to be extremely low compared to other areas of the project site. This area of low gradient flow directly corresponds to the area where glacial till and/or confining beds were found in the subsurface.

3. METHODOLOGY

3.1 Site Feature Selection

The initial site feature identification was conducted by the Army Geospatial Center (AGC) from a variety of historical sources. AGC utilized aerial photography from several date ranges (including as early as 1943) to assist in the identification of specific areas utilized for military operations. The 1986 and 1989 contract as-built drawings for the removal of military debris from the former Fort Morrow provided extensive data on the location and former use of hundreds of individual buildings and site features. AGC also utilized historical photographs and miscellaneous maps located in the National Archives, College Park, Maryland to determine the historical use of individual features and to pictorially validate the locations of suspected possible storage and or release sites. An example of the photographs used to initially identify site features to be examined is shown in Figure 3-1. The AGC also extensively used the Narrative Report of Alaska Construction 1941-1944, authored by James D. Bush, Jr. in 1944 (Bush, 1944).

A geodatabase of the data was created by the USACE to identify and track the individual site features.

The USACE used meetings with project stakeholders to facilitate the planning of the RI. Systematic planning is considered the first leg of the EPA Triad Approach and sets the goals of the remainder of the Triad (EPA, 2005). The three main elements associated with the Triad Approach include:

- Systematic planning,
- Dynamic work strategy, and
- Real time measurement systems.

The Triad Team met to discuss and plan the Fort Morrow RI on seven occasions. The Triad planning group included members of the impacted local community (Port Heiden), USACE representatives, ADEC, and the RI contractor (North Wind). Individuals from several other entities attended some of the planning meetings. The Triad Team used the list of site features developed by the AGC and USACE and previous preliminary sampling to identify the list of COPCs and to plan the RI. Decisions regarding the conduct of the RI were made by mutual agreement of all of the involved stakeholders.

Ammunition storage, munitions dump sites, defensive position ranges, and gun emplacements were not evaluated under this investigation but will be addressed as part of the USACE's Military Munitions Response Program (MMRP) at a later date.

Release sources that are identified as having been associated with Air Force operations subsequent to the closure of Fort Morrow were also not investigated under this RI.

A total of 1,269 individual possible site features located in 13 AOCs (AOC A through M) were identified by the AGC and Triad Team in the area of the former Fort Morrow. A total of 161 of these site features were found to be hazardous, toxic, and radiological waste (HTRW) funding ineligible, as they are features associated with the MMRP. A total of 15 sites from the database are associated with Air Force operations and have been excluded from this RI. Therefore, the total number of identified features to be evaluated under this entire RI is 1,093. A total of 330 of these site features were identified for evaluation as part of this phase of the RI (Table 3-1). The remaining site features in AOC A, AOC B, and AOC M will be evaluated during a later phase of the RI. Additional features were added by the field team, as they were discovered during the RI. In a few instances, the field team found that the site features had been eroded away by tidal action or had been removed. In these cases the features were removed from further investigation.

Characterization activities were generally divided into field screening activities and the collection and laboratory analysis of soil and groundwater samples. Field screening was used to focus the area and extent of the analytical sampling.

Table 3-2 lists the 32 types of identified site features found at Fort Morrow and their associated abbreviation used in the report.

Site features were divided into two categories of features depending on the likely possibility for the release of significant contamination to the environment. Site features that had a lower probability of large releases were screened at a frequency of 25% of their total occurrence within any given AOC and sampled at a frequency of 10% of their occurrence within the AOC. This frequency of screening included site features designated as quarters, buildings unknown and ground scars. Site features that had the greatest potential of larger scale releases were screened and sampled at 100% of their locations. These features included such sites as drum storage areas, buried drums or debris, warehouses, latrines, and others not listed for the 25% screening category.

The specific COPCs and the rational for selection are described in the RI Work Plan (North Wind, 2012).

A generalized flow chart showing the flow of field screening and sampling is included as Figure 3-2.

3.2 Field Identification of Site Features

The field screening process was started by the field crew identifying the specific site feature to be characterized. The individual site feature coordinates were loaded into the field GPS units. The field crew then located the site feature by utilizing the data programmed into the GPS unit. It was found that the features in both AOC C and AOC L were offset from their pre-programmed locations. This was caused by errors in the geo-reference data for the aerial photographs used to initially identify the site feature. After locating the coordinates of the feature, the field crew evaluated the surrounding area to determine if the programmed feature boundary was correct, or if it should be expanded or reduced in size. The field crew adjusted the area to fit within the actual ground scars or remaining site features such as foundations. The crew then staked the feature with a wooden lath with the feature number clearly marked. The crew then photographed the site feature and recorded the actual feature boundary with a GPS unit.

The field crew then laid out the screening grid and marked the location of individual screening points with pin flags. The grid spacing was laid out as specified in the approved Work Plan for each type of feature. The grids were adjusted from the Work Plan locations to fit the maximum number of screening points within the actual feature boundaries. Pin flags were marked as to what type of screening was required (i.e., UVOST, x-ray fluorescence [XRF], or if PCB sampling was required).

The crew then evaluated the feature area for any obvious signs of contaminated soils or for visual clues to contamination such as distressed or discolored vegetation.

3.3 Field Screening

Field screening was completed as specified in Table 17 of the Fort Morrow Work Plan (North Wind, 2012), except as noted. Any deviations from the Work Plan prescribed screening activities are described within the appropriate AOC specific subsection located within Section 4 of this report. A generalized description of the screening conducted during the RI is included below.

Multiple types of field screening were conducted to more accurately focus the sample collection for laboratory analysis. These screening methods included UVOST, radiological gamma and alpha screening, and XRF screening.

3.3.1 UVOST

North Wind utilized the UVOST system with one of two direct push "Power Probes®". The use of the UVOST system by direct push drilling enabled North Wind to delineate POL contaminants in the subsurface at the former Fort Morrow site by the fluorescence response of their polycyclic aromatic hydrocarbon (PAH) constituents. Figure 3-3 shows the North Wind drill rigs advancing UVOST and sample boreholes at the AOC K recreation 002 (K-RC-002) site feature.

A correlation comparison was conducted (described in Section 3.10) to determine the proportional response based on the non-aqueous phase liquid (NAPL) concentration of POLs specific to Fort Morrow soils. The correlation evaluation determined that a LIF of greater than 1% above the *insitu* background fluorescence may indicate an exceedance of the PAL and should be evaluated by laboratory sampling of the soil within that specific feature.

The use of real time screening for NAPL distribution provided a unique capability to rapidly characterize each site feature allowing real time decisions and adaptive site characterization capability as promoted by the EPA approach and adopted by this project (EPA, 2005). The field team was able to make real time decisions to add additional "step out" screening locations to determine the aerial extent of contamination. The team also used the UVOST data to determine the location for collection of laboratory samples to determine the nature of the investigated contamination.

UVOST logs for all of the completed screening boreholes are included in Appendix E.

3.3.1.1 Insitu Screening

UVOST field screening began on June 21, 2012 in AOC C. UVOST screening proceeded from AOC C, D, E, F, I, H, L, J, and K (AOC G had four soil screening samples collected via grab sampling a stainless steel hand auger because the site was inaccessible to the drill rigs). The last site feature was screened on October 13, 2012 in AOC K.

UVOST boreholes were advanced at each of the marked grid locations within the selected site features. Site features "Ground Scars (GS)," "Quarters (QT)," and "Building Unknowns (BU)" were screened at a frequency of 25% of the total number of those specific features within a specific AOC. All other features were screened at a frequency of 100%. The frequency of screening and the size of the screening grids are shown in Table 3-3.

The UVOST borings were advanced to a depth of approximately 2 feet below the static groundwater table. The groundwater at a site feature was measured with an electrical water level indicator within the first borehole advanced. The depth to water was recorded in the UVOST logbook and the depths of the subsequent boreholes were adjusted accordingly.

Operation of the UVOST laser was conducted in accordance with the Work Plan Standard Operating Procedure (SOP) and the manufacturer's operating manual. Operation of the UVOST system was conducted only by personnel trained by the manufacturer. Additionally, Dakota Technologies (UVOST manufacturer) provided North Wind personnel 2 weeks of on-site mentoring. Boreholes were only advanced when laser intensity was within specification. Following the advancement of the borehole and withdrawal of the laser probe from the soil, a single waveform was collected with the RE vial in place on the probe window. The resulting RE was then recorded and was compared to the initial RE before probe advancement. The log files were recorded onto the hard drive of the UVOST field computer and were backed up to the office computer and an external hard drive nightly.

The UVOST boreholes were abandoned in accordance with the Work Plan SOP and ADEC guidance (ADEC, 2010b) with dry 3/8-inch diameter bentonite chips that were hydrated as the borehole was backfilled from the bottom to the ground surface. The boreholes were flagged with the UVOST borehole number and then surveyed with a GPS unit with decimeter accuracy.

The borehole UVOST log was then examined by a trained UVOST operator and a real time decision was made as to the possibility of subsurface contamination. Additional UVOST borings were advanced in the event that subsurface contamination was present. UVOST “step-out” borings continued until the extent of the contamination had been delineated in all eight cardinal and inter-cardinal (ordinal) directions (e.g., N, NE, E, SE, and S). In some cases, notably the warehouse (“WH”) features in AOC J, the terrain precluded the “stepouts” being advanced on the normal grid spacing.

3.3.1.2 Borehole Constraints

The advancement of boreholes was constrained by several factors, such as the accessibility for the drill rig and geologic subsurface conditions.

The advancement of UVOST borings to depths greater than approximately 25 to 30 feet within AOCs J, K, and the southern portion of L was problematic due to subsurface cobbles and boulders associated with the underlying glacial till. The UVOST probes were advanced with a Bobcat mounted Power Probe model 9630 VTR-M or with a track mounted AMS, Inc. (AMS) Power Probe model 9500 VTR. North Wind has upgraded the 9500 VTR rig hammer to provide more foot/pounds of impact. A hammer dampener system was initially used with the AMS 9500 VTR to reduce fiber optic and shock protected optical casing (SPOC) failure due to impact loads. No hammer dampener was required with the Bobcat mounted Power Probe. It was found that the advancement of probes into or through the glacial till required the removal of the hammer dampener and full hydraulic hammer pressure. The penetration of the glacial till resulted in the shearing of multiple SPOCs. Therefore, boreholes were not advanced through subsurface materials that required excessive hammering. Several site features were found to have excessively steep sides, were surrounded by very pronounced tundra tussocks, or were located in wet soils incapable of supporting the drill rigs.

3.3.1.3 Hand Auger UVOST Screening

UVOST screening was conducted by hand auger boreholes in areas that were inaccessible to the drill rig. Hand auger boreholes were typically advanced to a depth of 8 feet bgs with the soil material placed into re-sealable plastic bags in 1-foot increments. The material was then run on the UVOST system in emulation mode with a minimum of 10 measurements per foot.

3.3.1.4 UVOST Log Generation

The Dakota Technologies optical screening tool (OST) software generates a graphical log (Figure 3-4) as the probe is advanced into the subsurface or as soil is placed onto the window in emulation mode. The software generates two important data files during data collection. The two files for each borehole are included in this RI report in Appendix E.

The computer file (.lif.raw.bin) is the OST raw data file. The header is ASCII format and contains information stored when the file was initially written (e.g., date, total depth, max signal, gps, etc., and any information entered by the operator). All raw waveforms are appended to the bottom of the file in a binary format. This file contains the information used to generate graphical logs at a later date.

The OST program also exports a lif.dat.txt file. This file is a data export of a single raw file. The file is stored in ASCII tab delimited format. No string header is provided for the individual columns (to make importing into other programs easier). Each row contains data that are for a unique depth reading. The individual columns are:

- Depth,
- Total Signal (%RE),
- Ch1%,
- Ch2%,
- Ch3%,
- Ch4%,
- Rate,
- Conductivity Depth,
- Conductivity Signal, and
- Hammer Rate.

Summing channels 1 to 4 yields the Total Signal.

Each area of the UVOST log presents specific information relevant to the individual borehole and depth. The portions of each UVOST log and their interpretation are listed below.

Main Plot Area: The signal (total fluorescence) versus depth is plotted in this area. The signal is plotted relative to the RE. The UVOST system is calibrated to the RE before each and every borehole. Additionally, the system is checked following the borehole to determine the change in laser intensity during the collection of the data. The total area of the waveform is divided by the total area of the RE waveform yielding the %RE. This %RE scales with the amount of NAPL fluorescence found in the soil at a given depth. The fill color is based on the relative contribution of each of the four channel's area to the total waveform area (refer to callouts on Figure 3-4). The colorization scheme uses red/green/blue (RGB) calculations of the relative areas of the 350, 400, 450, and 500 nanometer (nm) channels to generate RGB fill color. The channel to-color relationship and corresponding wavelengths are given in the upper right corner of the main plot.

Callouts: The operator may select waveforms from specific depths or from depth ranges to show the multi-wavelength waveform distinct to that depth. The four peaks are due to fluorescence at four separate wavelength bands (40 nm wide) and referred to as “channels”. Each of the four channels is assigned an individual distinct color. Various NAPLs will have a unique waveform "fingerprint" due to the relative amplitude of the four channels and/or broadening of one or more of the channels. Basic waveform statistics and any operator notes are given below the callout. Time is along the X axis in any given callout. No scale is shown in the callout box; however, each box is a standard 320 nanoseconds wide.

The Y axis is measured in millivolts and directly corresponds to the amount of light striking the photodetector. Callouts can be a single depth or a range (as shown in Figure 3-4). The depth range of the callout is noted on the depth axis by a bold line. When the callout is a range, the average and standard deviation in %RE is given below the callout.

Rate Plot: The rate of probe advancement is graphically displayed in this plot. A rate less than 0.8-inch per second is the preferred penetration rate. A noticeable decrease in the rate of advancement of the probe may be indicative of difficult probing conditions (e.g., gravel, angular sands, etc.) such as that seen at approximately 16 feet bgs. It should be noted, however, that penetration rate is greatly dependent on other drilling parameters, such as down pressure, hammer rate, and hydraulic flow rate. The probe operator can control these parameters to maintain constant penetration rate even with varying geologic conditions.

Info Box: This portion of the log contains pertinent log information, including the borehole name and location.

3.3.1.5 UVOST Log Interpretation

UVOST logs were evaluated by the certified UVOST operator as the data were collected. An attempt was made to determine in real time whether or not the UVOST probe had penetrated soils that may contain POL contamination above regulatory levels. It was found during the correlation evaluation that a fluorescence less than 1% above the borehole *insitu* background was consistently below PAL concentrations.

Individual types of fuels or other organic material will fluoresce in characteristic manners. Fuels with predominantly smaller PAHs fluoresce in the lower wavelength channels while heavier PAH molecules fluoresce in the longer wavelength channels. The ratio of peaks from one channel to another channel varied with different types of observed fuels. The other aspect of LIF that was evaluated was the time delay of fluorescence. The time delay is shown in the callout section by “tails” extending to the right of each of the channels. The specific delay in the end of fluorescence is also a characteristic of specific fuels. Figure 3-5 illustrates several common fuel LIF waveforms as well as many waveforms seen in the subsurface of several of the site features at the former Fort Morrow site.

The surface vegetation and two common subsurface stratigraphic horizons were found to be laser fluorescent at the project site. These LIF waveforms can be seen in the three bottom right examples of fluorescence shown in Figure 3-5. It was found that naturally occurring high LIF zones had very short time delay in their fluorescence (very narrow peaks in all channels). Additionally, for naturally occurring strata, it was observed that the 450 nm (orange) channel tended to be the highest LIF with the 350 nm (green) channel being considerably lower. The field team quickly learned to recognize the characteristic signatures of naturally occurring vegetative mats and to tentatively exclude them for consideration of zones of contamination.

3.3.1.6 UVOST Data Reduction

The UVOST data were also evaluated post collection by removing the average *insitu* borehole fluorescence from the collected %RE. Figure 3-6 illustrates an UVOST log from the AOC L building unknown 009 (L-BU-009) site feature. The *insitu* background %RE values are shown as specific zone call outs. In this example, the surface vegetation has a natural fluorescence of 3.2%. There is no contamination present even though this depth range shows an elevated %RE. Other geologic strata exhibit other *insitu* fluorescence. These %RE represent the operating background of the UVOST system as well as the natural fluorescence of the geologic material. For example, fluorescence values as high as 15% were observed in vegetative materials at the AOC J warehouse 003 (J-WH-003) site feature. An analysis of individual UVOST logs within site features was done to subtract the “background” fluorescence from the observed measurements. Residual values above the background are believed to represent actual contamination and will be referred to in this report as “effective LIF”. Average effective LIF was computed for each 1-foot increment in site features that exhibit UVOST contamination signatures or waveforms.

3.3.2 Radiological Screening

A gross alpha/beta/gamma meter (Ludlum 3) was used to survey the x-ray building site feature in AOC C (C-XR-001). The Triad Team had determined that there was a remote possibility of radionuclide contamination associated with the x-ray unit itself. It is possible that the unit used a sealed cesium-137 or cobalt source in the generation of x-rays. Although unlikely, it is conceivable that the sealed source may have leaked into the soil. The radiation detection meter was calibrated by the manufacturer before being shipped to Port Heiden, and was tested with a check source prior to use. The background radiation levels of 10 site features in AOC C were determined and used as the value for comparison with readings obtained from site feature C-XR-001. The screening locations within site feature C-XR-001 were laid out as a grid with 10-foot centers. Soil was removed in 4-inch intervals from each screening location by a stainless steel hand auger to a total depth of 2 feet bgs. The soil was extracted from the subsurface using a hand auger, which was spread evenly onto a paper plate in a thickness no greater than 0.5 inches.

The radiation meter was set at 0.1 for maximum sensitivity and was set to slow for the response to take an average reading over a 2- to 3-second time range.

The probe was placed 0.5 inches above the soil to be screened and the probe was moved back and forth at a rate of 1 to 2 inches per second. Soil was returned back to the borehole of origin after the radiological survey of each screening borehole was completed. The results of the radiological field screening were recorded on field forms that are provided in Appendix F.

3.3.3 X-Ray Fluorescence

A hand-held Innov-X XRF unit was used in the screening of soils for metals. Use of the XRF analyzer on this project followed the EPA Method 6200, *Field Portable X-Ray Fluorescence Spectrometry for the Determination of Elemental Concentrations in Soil and Sediment* (EPA, 2007).

The project Work Plan specified that XRF screening be conducted for possible lead contamination that may be associated with lead additives in motor vehicle gasoline (MOGAS) and aviation gasoline (AVGAS) and areas associated with lead/acid battery storage. Neither areas of elevated gasoline contamination nor lead/acid battery storage were encounter during this phase of the investigation. Therefore, the XRF was not extensively utilized for field screening of site feature soils. However, a correlation evaluation was conducted to determine the efficiency of evaluating metals concentrations within the Fort Morrow soils in preparation for the next phase of the investigation. The correlation evaluation was also used to determine the comparability and requirement of sieving of the soil before screening.

The correlation study also evaluated the comparability of direct measurements made in accordance with the Innov-X manufacturer’s procedures versus measurements made on the soil following the sieving and drying of sample material. The results of the XRF field screening were recorded on field forms that are provided in Appendix F. Details of the XRF correlation evaluation are included in Section 3.10.

The quality assurance/quality control (QA/QC) program for the XRF analyzer followed the general site-specific QC directives found in the Quality Assurance Project Plan (QAPP). As stated in SOP-23, "XRF Screening," the QA/QC program for the XRF included:

- An instrument blank was analyzed each working day before and after analyses were completed and also once per every 20 samples. No contamination was suspected based on the instrument blank results.
- A calibration check was performed for every 20 samples and at the end of each analytical sequence. All results passed the calibration checks.
- Field duplicates were conducted every 20 samples. The duplicate results for July and August 2012 show that the XRF readings for lead, arsenic, and chromium are exactly the same (relative percent difference [RPD] = 0%). The duplicate results for October 2012 also show that the XRF readings for these three analyses are exactly the same for each pair of duplicates (RPD = 0%).
- A precision verification check sample was performed in August 2012. This precision sample was analyzed seven times in replicate. All results for lead were less than the limit of detection (LOD); therefore, a relative standard deviation (RSD) could not be calculated.

3.3.4 Geophysical Survey

A geophysical investigation was performed by GeoTek, Alaska (GeoTek) at 17 site features in AOCs B, C, D, E, and F. The objective of the geophysical screening was to locate areas of buried drum caches, metal debris, USTs, and assorted other underground utilities.

3.3.4.1 Survey Area

Within these five AOCs, the geophysical survey consisted of acquiring electromagnetic (EM) and Global Positioning System (GPS) data at 17 site features. The individual sites were determined by the Triad Team during the RI planning process. The individual geophysical survey sites are listed below:

<u>AOC B</u>

- Drum Storage, B-DS-001
- Drum Storage, B-DS-002
- Latrine, B-LT-001 (Outfall)
- Mess Hall, B-MH-001
- Mounded Material, B-MM-002
- Mounded Material, B-MM-003
- Quarters, B-QT-043.

<u>AOC C</u>

- Buried Drums, C-BD-001

- Mounded Material, C-MM-001
- Mounded Material, C-MM-002.

AOC D

- Drum Storage, D-DS-001.

AOC E

- Drum Storage, E-DS-001
- Drum Storage, E-DS-002
- Drum Storage, E-DS-003.

AOC F

- Buried Drums, F-BD-001
- Drum Storage, F-DS-001.

3.3.4.2 Data Acquisition

EM data were acquired at every site shown above (using either an EM61 or EM31 instrument). The EM data acquisition was conducted over a 4-day period during the period of June 28, 2012 to July 2, 2012. In general, the majority of grid areas were 60-feet × 60-feet. However, several grids deviated from this area and ranged from 30-feet × 60-feet at site feature B-MH-001 to a larger area at the site feature D-DS-001 of approximately 140-feet × 200-feet. Each of the grid areas were designated by the work plan and identified by North Wind and GeoTek Alaska field personnel prior to data acquisition.

For the majority of the EM data acquisition within established grids, the grid line spacing was a nominal 5 feet. Typically, the EM61 instrument was attached to wheels and pushed across the ground along established grid paths. The EM61 data were acquired continuously at a frequency of 10 readings per second. Due to the terrain and vegetation cover on some of the site features, it was determined that the EM31 instrument provided better accessibility at those locations. For three of the site features (E-DS-002, E-DS-003, and F-BD-001), the EM data were acquired using an EM31 instrument carried by hand along the grid paths also with a nominal 5-feet line spacing. The EM31 data were also acquired continuously at ten (10) readings per second.

While smaller pieces of surface metal was present within several of the grid areas, the time allotted for EM data acquisition did not allow for the GPS location of individual items of surface metal. At two site features (E-DS-001 and F-BD-001), large or obvious pieces of surface metal were noted.

Instrument calibrations were verified prior to mobilization to Port Heiden. Additionally, instrument response tests were performed daily before data acquisition and at the end of data acquisition. For the EM31 instrument, all equipment functional checks were performed prior to and after data acquisition at each grid site.

3.3.4.3 Instrumentation

The instrumentation used to acquire the EM data is the Geonics EM61-MK2 and the Geonics EM31-MK2. When using EM data it should also be understood that for a target to be detectable, several conditions must be met. Generally, three (3) conditions apply and they are; 1) the transmitted signal must induce currents inside the target. In the case of a resistive target, induced currents must flow around the target, 2) there must be a difference in electrical properties between the target and the surrounding material to generate an anomalous electromagnetic response, and 3) the anomalous electromagnetic response must be large compared to any noise signals or background response.

The following sections provide a brief description of the equipment used for the data acquisition of the geophysical data.

Geonics EM61-MK2

The Geonics EM61 is a high sensitivity, high-resolution, time-domain electromagnetic metal detector that detects both ferrous and non-ferrous metallic objects. The EM61 instrument is used for acquisition of electromagnetic data to identify anomalies associated with buried metal objects, including ferrous and non-ferrous metals.

The EM61 instrument consists of two coils mounted one above another on the coil assembly that serve as both transmitter and receiver. A steady voltage is applied to the lower or transmitter coil (peak power of 100 watts) that is sharply terminated at each cycle or pulse. A rapid reduction of the transmitter current, and thus of the associated primary magnetic field, induces an electromotive force in nearby conductors (i.e., metallic objects). This electromotive force causes electrical eddy currents to flow in conductors with decay characteristics that are a function of the conductivity, size, and shape of the conductor. The decaying currents generate a secondary magnetic field that is detected and measured by the two coils now acting as receivers. The measurements are made at a relatively long time (0.45 milliseconds) after termination of the primary pulse. This delay in measurement provides for a response that is practically independent of the electrical conductivity of the ground due to the longer decay characteristic of electrical eddy currents in metallic objects than that of the ground. The measured response from the secondary magnetic field is proportional to the metal type, mass, shape, and depth of the conductor.

The effective depth of exploration of the EM61 is based on several factors (but not limited to) such as; type, mass, shape, and depth of metal object. For example, based on empirical data for a buried 55-gallon drum the EM61 has a depth of investigation of approximately 9 feet (a 55-gallon drum buried at 9.8-feet produces a 3 mV response in the Top Channel). Generally, the most common way of interpreting EM61 data is to use the bottom and the differential channels.

Geonics EM31-MK2

The Geonics EM31-MK2 is a ground conductivity meter. Based on the design principles of inductive electromagnetics, ground conductivity meters provide a non-invasive method for measurement of subsurface conductivity and magnetic susceptibility. Without any requirement for soil-to-instrument contact, surveys can be performed quickly – facilitating dense data collection and, consequently, excellent spatial resolution – and over most geologic environments, including conditions of highly resistive surface materials such as sand and gravel. As a recognized standard for applications in environmental site characterization, the EM31-MK2 provides measurement of apparent conductivity and magnetic susceptibility.

The EM31-MK2 maps geologic variations, groundwater contaminants, or any subsurface feature associated with changes in ground conductivity. The instrument uses a patented electromagnetic inductive technique that allows measurements without electrodes or ground contact. With this inductive method, surveys can be carried out under most geologic conditions including those of high surface resistivity such as sand, gravel, and asphalt.

Ground conductivity (quadrature) and magnetic susceptibility (in-phase) measurements are read directly from a data logger (which provides for simple data transfer). The data logger also provides for the Real Time (RT) graphical presentation of the data during acquisition.

The effective depth of exploration is approximately 20 feet, making it ideal for geotechnical and environmental site characterization. Important advantages of the EM31-MK2 over conventional resistivity methods are the speed with which surveys can be performed, the precision with which small changes in conductivity can be measured and the continuous readout and data collection while traversing the survey area. Additionally, the in-phase component is particularly useful for the detection of buried metallic structure and waste material. Typically, the EM31 in-phase component will detect a single 55-gallon drum to depths of approximately 6.5-feet.

The basic principle of operation of the EM31 instrument is simple. A transmitter coil located at one end of the instrument induces circular eddy current loops in the earth. Under certain conditions fulfilled in the design of the instrument, the magnitude of any one of these current loops is directly proportional to the ground conductivity in the vicinity of the loop. Each one of the current loops generates a magnetic field that is proportional to the value of the current flowing within that loop. A part of the magnetic field from each loop is intercepted by the receiver coil and results in an output voltage. Thus, the output voltage is also linearly related to the ground conductivity. The instrument is calibrated to read the correct conductivity when the earth is uniform. The unit of conductivity used is milliSiemens per meter (mS/m).

There are two components of the induced magnetic field measured by the instrument. The first is the quadrature component that provides the ground conductivity measurement, and the second is the in-phase component used primarily for calibration purposes. However, the in-phase component is significantly more sensitive to large metallic objects and is very useful when looking for buried metal objects (e.g., tanks and drums). In general, the in-phase component is a better detector of metal, but the quadrature is more sensitive to long, extended targets (e.g., pipelines) that are, at least partially, in electrical contact with the ground.

3.3.4.4 EM Data Processing

Preliminary processing of the EM data was performed in the field using state-of-the-art processing software, Geosoft's Oasis montaj v7.5. Final processing of the EM data using Geosoft's Oasis montaj v8.0 was completed at the GeoTek office in Anchorage, AK.

The quality of the acquired EM data is good (on a scale of good, fair, poor) for every grid or reconnaissance area. As previously mentioned, a different method (i.e., EM31) was used for data acquisition at site features E-DS-002, E-DS-003, and F-BD-001. No background removal was performed on any of the EM data, and a unique color scale for each grid was determined to be the prudent technical method for the display of the EM color contour maps.

3.3.4.5 Control Surveying

Prior to the acquisition of geophysical data at the survey grids within a regional area, a GPS base station was established to enable the acquisition of a Real Time Kinematic (RTK) GPS location (submeter grade accuracy) of the geophysical data. Once the base station was established, all of the GPS location data for the geophysical survey were corrected based on the established base station location.

The geophysical grids were constructed using cloth tapes to sufficiently cover the area of investigation. Wooden lathe were inserted in the ground at the start and end of every other grid line. Location maps for the line paths of the data acquisition within a geophysical survey grid are included in the report figures.

GeoTek used a Leica 1200 System to acquire position data for the geophysical survey data. Location data were referenced to an established base station. All positioning data were acquired in the field using the WGS84 datum and geographic coordinate system (latitude and longitude). The positioning of the geophysical data was transformed post survey to a NAD83 Datum and Alaska State Plane Zone 6 (ASP Z6) coordinate system. All geophysical data positioning and maps in this report are displayed using the NAD83 Datum and the ASP Z6 coordinate system. The map units are in US survey feet.

3.3.4.6 Visual Presentation

Prior to a discussion of the results for the EM data acquired at the project sites, it is important to understand how the color display/contour maps of the geophysical data were produced.

The mapping and identification of any EM data anomalies at a project site were accomplished by producing color contour maps of the acquired data. The geophysical and location data acquired at a project site consists of a measurement made by the geophysical instrument at a specific location (x,y). The unit of measurement for the EM61 instrument is millivolts (mV). The units of measurement for the EM31 is mS/m for the conductivity component and parts per thousand for the in-phase component. Depending on the depth of burial, metal (surface or subsurface) will normally produce anomalously high data values from the surrounding background instrument readings within an appropriately designed survey grid. The instrument readings are mapped by processing the data in conjunction with the location data to produce color contour maps of the geophysical data. Anomalously high data values or peak values are then identified by choosing the appropriate colors and contour intervals to enhance the differentiation of the peak or anomalous data values from the background data values for each project site. In addition to producing color contours of the data, the map has also been shaded to produce an appearance of relief of the color contour surface to further enhance the identification of peak data values. It should be noted that the color scale for producing the color contour maps at each survey site is relative to the range of data values measured at a particular site. Thus, the color scale for one survey grid will not be the same for another survey grid. This color scheme provides the ability to emphasize the higher data values for the range of data values within each data grid. Using a consistent color scheme for all of the data grids does not produce a method for highlighting the higher data values within each grid. For the color contour figures included in this report, a color scheme has been selected for each grid that assigns hot colors (magenta, pink, red, etc.) to the higher data values, cooler colors (orange, yellow, greens, etc.) for the mid-range data values, and blues and gray for the low or background values.

3.4 Sample Collection Methodology

The following sections address field methodology for the collection of soil and groundwater samples. Data QA/QC parameters are discussed in the Chemical Data Quality Report (CDQR) (Appendix G). Field sampling of soil and groundwater was carried out in accordance with the project Work Plan. Copies of the soil boring logs are provided in Appendix H.

3.4.1 Soil Sampling

The soil sampling conducted at the former Fort Morrow site followed procedures set forth in the ADEC "Draft Field Sampling Guidance" (ADEC, 2010b). Soil samples collected during this investigation were discrete samples and were not composited before analysis, except when required by federal regulations (e.g., Toxic Substances Control Act [TSCA] for PCBs or Resource Conservation and Recovery Act [RCRA] waste disposal characterization).

The location and depth that the samples were collected from was entirely predicated upon the screening results. Samples were collected from the location and depth of the maximum concentration of POL contamination, as determined by total %RE fluorescence with the UVOST. Samples were taken from the largest thickness of contamination if multiple areas were identified with similar %RE. The sample collection was planned to be based upon the XRF data for features in which lead was the primary contaminant of concern (COC). No areas with high lead concentrations from gasoline range organics (GRO) or batteries were identified in this phase of the RI. However, one sample for metals within site feature J-WH-002 was located and collected due to the presence of a broken battery casing.

Additional samples were collected at features where the total number of screening points exceeded 10. The total number of samples at these large area features was established by the Work Plan at 10% of the total screening locations. These additional samples were collected for POL compounds (GRO, diesel range organics [DRO], residual range organics [RRO], and benzene, toluene, ethylbenzene, and xylenes [BTEX]) only. The sample locations were again tied to the areas and depths of the highest concentrations of detected contaminants by UVOST. However, as determined by the Triad Team and the Work Plan, an effort was made to collect the samples from boreholes that represent the entire spatial distribution of the contaminant. The Triad Team agreed that if no contamination was detected by screening, the required sample would be collected from the top of mineral soil (below and surface vegetation and root masses) or at the piezometric smear zone.

3.4.1.1 General Requirements for Collection of Soil Samples

- Use of clean stainless steel trowels and spoons to collect sufficient material to fill the sample containers.
- All soils collected for parameters other than volatile organic compound (VOC) and GRO were homogenized (ADEC, 2010b).
- Caps on sample containers were immediately secured after sample material was placed in them. Containers were labeled with the appropriate information.
- Samples were recorded in the field sampling logbook (including sample identification [ID], location, depth, method, date and time).
- Sample locations were marked with a labeled pin-flag and a GPS location was recorded to sub-10 centimeter vertical accuracy.
- Samples were packed in a cooler with ice and preserved to 4°C ± 2°C under temporary custody of North Wind field personnel. VOC and GRO samples were preserved with 25 milliliters (mL) of methanol.
- Non-disposable sampling equipment was decontaminated at each sample location to minimize cross-contamination.
- When field duplicate samples were collected, jars for volatile organic analyses (VOAs) were filled first. The remaining soil was homogenized and the other parameters collected.
- Sample parameters were collected in the following order:
  - VOCs (GRO and BTEX);
  - Semivolatile organic compounds (SVOCs), pesticides/herbicides, DRO, RRO, and PCBs; and
  - Metals.

3.4.1.2 Volatile Soil Sampling Methodology

Stainless steel spoons, scoops and trowels were used in the field to collect volatile sample because they result in less soil disturbance and volatile loss than other sampling techniques. A minimum of 25 grams of soil with minimum disturbance were placed directly into a tared 4-ounce jar with a Teflon-lined septum fused in the lid. A 25-mL aliquot of methanol and alpha-alpha-alpha-trifluorotoluene (a surrogate tracer for method AK101) was added to the sample jar until the sample was submerged. Samples were then placed in a cooler with ice and preserved to 4°C ± 2°C.

In the event that only the VOA suite was to be analyzed, a second jar was filled with the same material from the same location in an unpreserved jar for percent moisture determination. If the VOA suite was not the only suite to be analyzed for, VOC, GRO, and/or BTEX were collected first with minimum disturbance as described above.

3.4.2 Surface Soil Samples

Collection of soil samples from near-surface soil was accomplished with clean, un-plated, stainless steel shovels, spades, and trowels. Once a location was identified for surface soil sample collection, surface material was removed with a shovel or trowel and then a clean stainless steel spoon or scoop was used to collect the sample. If volatile organic analysis was to be performed, the sample material was transferred directly into an appropriate sample contained, preserved with methanol, and the cap secured tightly. The remaining sample material was then placed in a stainless steel bowl for homogenization and mixed thoroughly in order to obtain a homogenous sample representative of the entire sampling interval.

3.4.3 Nine Point Composite PCB Samples

Sampling of surface soils for PCB analysis was conducted following composite grid sampling protocol. A 10-foot grid was laid out over the area. Soil sample material from adjacent nine point grids was composited. The surface grids were extended to cover the entire feature and surrounding area to be evaluated with a total number of grid sample points divisible by 9. Grid sizes were decreased to 5 feet in areas of known PCB contamination.

A clean non-plated stainless steel shovel was used to remove the top 6 inches of soil. Sample material was collected from approximately 6 inches below the soil surface. One dedicated steel sampling spoon was used to scoop soil from each of the nine locations within the grid. This volume was approximately 25 grams per spoonful. These nine scoops were then homogenized and then deposited into an 8-ounce sample container. The sample jars were then labeled and prepared for shipment to the analytical laboratory. PCB soil samples were preserved to 4°C ± 2°C.

3.4.4 Sampling at Depth with Hand Augers

This sampling system consisted of a stainless steel hand auger, a series of extensions, and a “T” handle. The surface around a sampling location was cleared of surface debris and the first 3 to 6 inches of surface soil were removed. It was sometimes necessary to clear the surface material in a 6-inch radius around a sampling location if there were thick surface vegetation or a root mat. Once hand augering began, material was removed from the hole in 6- to 8-inch “lifts” of the auger bucket. This material was placed onto a plastic sheet spread near the borehole. Once the sampling depth was reached, the hand auger was removed from the borehole with the correct interval of soil to be sampled. The advantage to this sample system is that it was used to sample site features that were inaccessible to the direct push drill rig.

When collecting for VOA parameters, a stainless steel sample spoon was used to collect soil from the auger bucket with minimum disturbance to minimize volatile loss. This soil was placed in an appropriate labeled sample container and preserved with methanol. The remainder of the sample was placed into a stainless steel bowl and homogenized so that a sample representative of the entire sample interval could be collected. The sample material was then placed into appropriate, labeled containers and the lids were secured.

3.4.5 Sampling at Depth with a Direct Push Drill Rig

This sampling system consisted of a direct push drill rig, probe drive string, and a lexan liner inserted within the direct push extension. The probe drive string and lexan sampler were advanced through the soil to obtain a continuous core of the soil. The lexan tubes are then removed from the drill string, opened, and a soil sample collected. The advantage to this soil sampling method was that it was used to collect continuous soil cores from a site feature allowing the subsurface geology to be logged per American Society for Testing and Materials (ASTM) standards (borehole logs are presented in Appendix H). An example lithologic log is shown in Figure 3-7.

A stainless steel sample spoon was used to collect soil from the lexan tube for VOA analysis. The soil was collected immediately after opening the lexan sample tube. Care was taken to minimize disturbance to reduce volatile loss. The soil was placed in an appropriate labeled sample container and preserved with the laboratory specified amount of surrogate containing methanol. The remainder of the sample was placed into a stainless steel bowl and homogenized so that a sample representative of the entire sample interval could be collected. The sample material was then placed into appropriate containers, labeled, and the lids were secured.

3.4.6 Groundwater Sampling

The groundwater sampling conducted at the former Fort Morrow site followed procedures set forth in the ADEC “Draft Field Sampling Guidance” (ADEC, 2010b). Groundwater samples were collected using the low-flow procedure for groundwater sampling. All groundwater samples were grab samples and were not time or flow weighted composites.

3.4.6.1 General Requirements for Collecting Groundwater Samples

The low-flow method was used for collection of groundwater samples. Contaminant analytes were collected in the following order:

1. In-field water quality parameters (i.e., temperature, pH, turbidity, specific conductance, dissolved oxygen [DO], and oxidation reduction potential [ORP]);

2. VOCs, including GRO, BTEX, methane, and carbon dioxide (CO_2);

3. SVOCs, including DRO and RRO, PAHs, PCBs, pesticides, and herbicides; and

4. Metals.

3.4.6.2 Field Equipment Calibration

The water quality parameter Horiba® multimeter was calibrated daily before use. Field water quality measurements included temperature (°C), pH, turbidity, specific conductance, DO, and ORP.

3.4.6.3 Equipment Selection and Decontamination

All reusable equipment and materials used for groundwater sampling were decontaminated before use. Decontamination of power probe rods and other equipment was conducted by first scrubbing with Alconox non-phosphate detergent and then rinsing in tap water. Decontamination of sampling equipment was conducted the same way but with a final distilled water rinse. Dedicated sample tubing was used for each individual well to reduce waste generation. A peristaltic pump was used with the dedicated tubing for purging and sampling of each monitoring well.

3.4.6.4 Collection of Field Water Quality Control Parameters

Once the dedicated polyethylene tubing was lowered to the desired sample intake depth, a peristaltic pump was turned on to the lower setting. The target rate of water flow was 1 liter every 3 minutes. After pumping for 1 to 2 minutes to allow for any high turbidity solids to pass through, the pump was turned off and the flow through cell assembly was installed to the Horiba® multimeter. Field water QC parameters were routinely measured every 3 to 5 minutes until they stabilized and three consecutive readings were recorded, meeting at least three (four if temperature is used) of the following parameters:

1. ±0.2 °C, temperature,
2. ±0.1 pH,
3. ±3% conductivity,
4. ± mV ORP,
5. ±10 parts per million (ppm) or 0.2 milligrams per liter (mg/L) DO, and
6. ±10% turbidity or ≤10 nephelometric turbidity units (NTUs).

In the event that a monitoring well could not support low-flow purge rates because of slow recharge, the well was drawn down. It was then sampled following full recharge without the collection of water quality parameters.

3.4.6.5 Collection of Groundwater Samples

Properly labeled groundwater sample containers were filled so that the sample was allowed to flow gently down the inside wall of the container, minimizing turbulence, agitation, and aeration of the sample. The headspace was minimized within the sample container.

Analytes requiring chemical preservative were preserved at the time of sample collection. These include VOCs preserved with hydrochloric acid (HCl) and metals preserved with nitric acid (HNO_3). All sample containers were then quickly sealed with Teflon-lined screw caps. All groundwater samples were then cooled to a temperature of 4°C ±2°C inside a standard cooler (or equivalent) under temporary site custody.

Samples were recorded in the field sampling logbook (including sample ID, location, depth, method, date, and time). A photograph showing groundwater collection methods is included as Figure 3-8.

3.4.7 Surface Water and Sediment Sampling

Surface water or sediment samples were not collected as no surface water bodies were found to be closely connected to petroleum contaminated groundwater. The only groundwater found to contain compounds above the PALs was near site feature AOC C latrine 002 (C-LT-002). It was determined that there were no bodies of water of more than 100 square feet located within 50-feet downgradient of this area.

Additionally it was determined that there were no bodies of water with surface area greater than 100 square feet located within 50 feet downgradient of any petroleum contamination in soil that exceeded the PALs.

3.4.8 Sample Handling, Packaging, and Shipping

Primary samples were identified with a unique naming convention that identified the sample area (AOC), location type, location number, media matrix and a unique sample number from that specific site and matrix.

1. The first two digits indicate the year (“12” for 2012).
2. The next two digits indicate the site (“FM” for Fort Morrow).
3. The fifth digit indicates the AOC (A through M).
4. The sixth and seventh digits will represent the feature type (e.g., “FS” for fuel storage, “SP” for shop, “TR for trench, etc.). Table 3-2 provides the listing of feature types.
5. The eighth and ninth digits will represent the specific feature number.
6. The next two digits indicate sample matrix (i.e., “DT” for soil, “GW” for groundwater, “CO” for correlation sample.
7. The final three digits represent the unique sample number from that specific site and matrix (i.e., 001 through 099).

Field duplicates were assigned a unique sample number and were kept blind from the laboratory (using fictitious location ID numbers) as a means to keep their analytical reports unbiased. The first digit for the field duplicates started with the number 9 (e.g., the duplicate for sample -028 was -928).

Chain-of-custody procedures were followed to ensure the possession and control of soil samples, groundwater samples, decontamination samples and QA/QC samples. Appropriate sample information was recorded in the field sampling logbook as well as on electronic chain-of-custody forms. Samples were kept in a dedicated sample refrigerator in a locked office building with limited access.

Samples were packaged the morning of the shipment day. Samples were bubble wrapped, and placed inside sealable plastic bags and were packaged in such a way as to minimize movement during transport, thereby reducing the risk of a sample jar breaking on the way to the laboratory. The sample coolers were packed with gel ice to ensure that samples maintained the proper temperature during shipment. Chain-of-custody seals, with unique ID numbers were affixed to the sealed coolers. Chain-of-custody paperwork was sent in each cooler and was also emailed to the analytical laboratory, Test America Laboratories (TAL) in Denver, Colorado.

Samples were shipped from the site, approximately once a week by chartered aircraft to Anchorage, Alaska. They were then shipped from Anchorage to TAL in Denver by GoldStreak Package Express. The sealed coolers were then picked up by a courier and delivered to TAL Denver.

3.5 Monitoring Well Installation

Monitoring wells were installed by direct push technology in accordance with the project Work Plan SOP, ADEC monitoring well guidance (ADEC, 2011), and ASTM D6725, Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers (ASTM, 2010).

Monitoring wells were installed by advancing a 3 ½-inch diameter direct push casing with expendable tip to the depth of the bottom of the proposed well. The bottom cap, prepacked well screen, expanding foam bridge, and polyvinyl chloride (PVC) riser were then installed into the direct push casing. The casing was then removed and the annular space above the foam bridge was sealed with bentonite. A track mounted AMS Power Probe 9500 VTR drill rig was used to install all prepacked monitoring wells. Figure 3-9 illustrates the installation method for direct push wells.

Table 3-4 lists the construction details for the monitoring wells installed during the RI.

A typical well construction as-built diagram is shown as Figure 3-10. As-built diagrams for all wells and piezometers are included in Appendix I.

All wells were developed after installation. Well development employed a surge-and-pump technique to remove fine materials from the surrounding aquifer and to establish a good hydraulic connection between each well and the surrounding formation. Development water was removed from each well during this process and temporarily containerized on site in 55-gallon Department of Transportation (DOT)-approved steel drums (or equivalent). Development water from all wells, with the exception of monitoring well C-MW-001, was found to contain no contamination above PALs. The approximate 150 gallons of uncontaminated water will be discharged during summer of 2013. Water from monitoring well C-MW-001 contained fuel contamination above the PALs. This water will be processed through a granulated activated charcoal (GAC) filter and discharged. The following steps were used at each well for development:

- Investigated each well for the presence of a light non-aqueous phase liquid (LNAPL) using an electronic oil/water interface probe.

- Measured and recorded the total depth of the well using an electronic water level indicator.

- Surged the 2–inch diameter wells with a stainless steel surge block. The surge block was lowered to the bottom of the well and then lifted 6 inches above the bottom.

- Surged each 2–inch diameter well over a 2– to 5–foot section of the well screen with 20 up and down cycles per section. The surge block was then raised to the next portion of the screen and the up and down cycle was repeated until all portions of the wetted screen area had been surged.

- Placed a 2–inch diameter, 12-volt submersible pump into the well; accumulated sediment and purge water was removed from the well. The pump was initially placed in the bottom of the well and was then moved slowly up and down through the water column to remove sediment and water from all portions of the wetted screen.

- Measured water levels in each well with an electronic water level indicator during pumping.

- Collected and stored all development water into 55-gallon DOT-approved drums (or equivalent) and awaited the results of groundwater sampling data.

- Locked the well and picked up the development materials. The surge block and submersible pump were decontaminated in an Alconox solution and rinsed.

3.6 Piezometer Installation

Piezometers were installed by direct push technology in accordance with the project Work Plan SOP in sample boreholes or in direct push boreholes with an expendable tip. Piezometers were installed to measure groundwater elevations to provide sufficient data points for groundwater flow direction and gradient computations. Samples were not collected from any of the piezometers installed. The piezometers were typically installed by advancing 2-3/8-inch diameter direct push casing. The bottom cap, well screen, and PVC riser were then installed into the direct push casing. The casing was then removed as the annular space was filled. Colorado silica sand was placed around the well screen to a depth several feet above the top of the screen. The remainder of the borehole was sealed with 3/8-inch bentonite chips. Table 3-4 lists the construction details for the piezometers installed at the former Fort Morrow.

As-built diagrams for all wells and piezometers are included in Appendix I.

3.7 Benchmark Installation

Five new benchmarks were installed during the 2012 RI to provide geographically dispersed benchmark locations for real time correction or post processing base stations for GPS data. The benchmarks also served for starting points for visual surveys of piezometers and UVOST points. Figure 3-11 shows the locations of the newly installed benchmarks. The benchmarks were installed following the standards for a Type A deep rod monument with 3-foot finned section, as specified in Engineer Manual 1110-1-1002 (USACE, 2012). An example as-built diagram and construction details are shown as Figure 3-12. A photograph showing typical construction of the benchmarks in included as Figure 3-13.

Online Positioning User Service (OPUS) solutions were obtained for the five newly installed benchmarks as well as two previously existing monuments. A summary of the OPUS solutions for all of the benchmarks is shown in Table 3-5. The complete OPUS solutions are included in the survey data compiled in Appendix J.

3.8 GPS Survey

North Wind surveyed the following locations during the field investigation:

- Soil borings,

- Monitoring wells,

- Piezometers,

- UVOST probes,

- Investigative field screening locations,

- Sample locations,

- Site feature boundaries, and
- Existing monuments found at a project site.

The 2011 Manual for Electronic Deliverables (MED) (USACE, 2011) required accuracy for these locations, with the exception of wells, is 1-meter of horizontal accuracy and 0.15-meters of vertical accuracy. North Wind utilized a Trimble GeoXH6000 GPS unit with post processing to meet the requirements of the MED for RI quality elevation data. The manufacturer specifications for this unit specify decimeter grade accuracy. North Wind originally used one GPS unit setup as a base station over one of the deep rod benchmarks. The second GPS unit was used as a rover to collect data in the field. The GPS units were then brought in from the field and downloaded to the field office computer. One unit then had the base station correction data and the other unit had the field data. Using the latest version of Pathfinder Office, the data were post process corrected to increase the accuracy. It was quickly determined that the use of the local Continuously Operating Reference Station (CORS) located near the Village Offices in AOC D enabled a higher accuracy of GPS collection.

The accuracy specified for the monitoring wells is a closed level loop at 0.01 feet per setup (or better). The elevation survey was tied to existing or new monuments. The monitoring wells were surveyed by a State of Alaska registered surveyor, PDC Engineers. The survey data for the monitoring wells are included in Appendix J. North Wind surveyed the elevation of piezometers utilizing a level line loop closed to an accuracy of 0.01 feet (or better). North Wind surveyed all piezometers from either the close bench mark or the closest surveyed monitoring well. Data for the piezometer survey are also included in Appendix J.

A Trimble Model 5800 was used to collect GPS data for the OPUS solutions. The OPUS solution data are also included in Appendix J.

North Wind personnel ran several survey loops from benchmarks to individual UVOST points in order to validate the GPS collected elevation data. Elevation data obtained by level line survey were then compared to the GPS data. Analysis shows that the GPS data in most cases meet the MED requirements as shown in Table 3-6.

It was found that the GPS data collected by North Wind had a vertical datum shift of approximately 2.8 feet from that obtained from the OPUS solutions. The Trimble export utility used was based upon the original WGS-84 datum definition, which was essentially the same as the original NAD 83 datum definition (called NAD 83 [1986]). However, since then, both of these datums have been redefined several times, and they can now differ by a meter or more. Because WGS-84 and NAD 83 (1986) were previously treated as the same, the coordinate system database (CSD) in the GPS Pathfinder Office software contains a “zero” NAD 83 datum transformation definition, which does not transform coordinates between WGS-84 and NAD 83. When North Wind exported the WGS-84 GNSS data from the GPS Pathfinder Office software to a GIS that used a coordinate system based on the “zero” NAD83 datum transformation, no transformation was performed and it appears the 2.8-feet datum offset was introduced. It should be noted that for this Draft Final Report, all elevation data are still comparable to each other, as all data contain the same offset. A Trimble “White Paper” describing the issue is included as Appendix K.

3.9 Vapor Intrusion Analysis

Vapor intrusion is the migration of volatile chemicals from a subsurface source into overlying buildings. There is the potential for people to inhale the contaminant vapors that migrate into a building. The vapor intrusion pathway should be considered complete if petroleum contamination is found within 30 feet, or, non-petroleum contamination is found within 100 feet of a building location or potential building location and if volatile compounds are found in soil or groundwater (ADEC, 2010).

- In AOC C, petroleum contamination was detected within 30 feet of a potential future building site and 2-methylnathalene and DRO are present in soils; therefore, the vapor intrusion pathway in AOC C is complete.

- In AOC D, petroleum contamination was detected within 30 feet of a potential future building site and MTBE is present in soils; therefore, the vapor intrusion pathway is complete in AOC D. MTBE was not a World War II era fuel additive and its presence is likely due to more current activities.

- In AOC E, petroleum and volatile compounds were detected in the soil and future building of residences could be reasonably expected in this area; therefore, the vapor intrusion pathway is complete in AOC E.

- In AOC F, volatile compounds were detected in the soil within 100 feet of a potential future building site; therefore, the vapor intrusion pathway is complete in AOC F.

- The vapor intrusion pathway is incomplete in AOC G. There is no potential future building sites in AOC G because there is standing water/muskeg swamp over the vast majority of this AOC. Methylene chloride was detected in one soil sample collected from AOC G; however, it is likely a laboratory contaminant and not an environmental contaminant. It will not be considered when determining exposure pathways.

- The vapor intrusion pathway is complete in AOC H due to volatile compounds (e.g., MTBE) being detected in the soil within 100 feet of potential future building sites along with petroleum compounds.

- The vapor intrusion pathway is complete in AOC I. Although the petroleum and volatile contaminants detected in soil in AOC I are at very low levels, there is the potential for future building in this AOC.

- The vapor intrusion pathway is complete in AOC J because petroleum and volatile compounds were detected in the soil within 30 feet of potential future building sites.

- In AOC K, the vapor intrusion pathway is complete. There is the potential for future building of residences and volatile and petroleum compounds were detected at low levels in soil.

- In AOC L, the vapor intrusion pathway is complete. There is the potential for future building and volatile and petroleum compounds were detected at low levels in soil.

3.10 Correlation Evaluation

Correlation studies were performed on soils to evaluate the efficacy of screening for POLs with UVOST technology and SiteLAB® field screening kits. In contrast to UVOST screening technology, the SiteLAB system can also detect heavy end PAH compounds. Correlation studies were also performed on soils to evaluate the efficacy of screening for metals with XRF technology. Results of these correlation studies are presented below.

3.10.1 Field Screening Correlation Studies for Metals

Correlation studies were performed on soils to evaluate the efficacy of screening for metals with an XRF instrument. Specifically, XRF correlation studies were planned to determine if lead contamination associated with lead additives in gasoline or lead/acid storage batteries could be detected and field screened. Soil for XRF correlation screening was split from the soil sample material that was collected for analytical laboratory analysis. Material was collected with a stainless steel hand auger or a direct push drill rig with a lexan sampling. The soil material was then homogenized and a subsample for XRF screening was transferred to a re-sealable plastic bag with the other split set aside for laboratory analysis. The XRF screening soil subsample was again split for duplicate XRF analysis. One fraction was measured with the XRF in accordance with the manufacturer's procedures using the Innov-X insitu soil mode. The XRF was operated in the intrusive mode and the probe window was placed in direct contact with the re-sealable plastic bag. The other fraction was sieved and dried as per previous USACE practice. This second fraction was sieved through a 2-mm screen and allowed to dry until the soil was below the 20% moisture content required by the work plan SOP-23. Soil was considered to have less than 20% moisture when it was dry to the touch. Soil was not baked in an oven so drying time was variable.

Unfortunately, the 2012 field activities were conducted within AOCs where lead concentrations were not detected at enough locations or at levels high enough to perform a complete correlation study. These limited results are presented below.

3.10.1.1 July and August 2012 Correlation Study

In July and August 2012, field screening was performed to compare XRF readings for sieved versus unsieved field soil samples. In addition, unsieved soil samples were sent to the off-site laboratory for metal analysis. Results are presented in Table 3-7. Samples were collected from six locations at AOC D. Since almost all of the XRF readings for lead and chromium are less than the level of detection (<LOD), comparisons of sieved XRF/unsieved XRF or unsieved XRF/laboratory results cannot be conducted. Arsenic has detected measurements; however, correlation evaluations are limited since all of the values are low and close to the detection limits.

The r^2 value (square of the correlation coefficient) is the fraction of the variation in the data that is accounted for by the regression line. A perfect correlation would result in an r^2 value of 1. Based on the regression curves and r^2 values, the correlation between sieved XRF/unsieved XRF and unsieved XRF/laboratory analysis is not comparable for low concentrations likely due to the high amount of scatter associated with data at low concentrations.

3.10.1.2 October 2012 Correlation Study

In October 2012, field screening was performed to compare sieved XRF readings to unsieved XRF soil samples. Results are presented in Table 3-8. Samples were collected from 17 locations in AOCs J and K. Since almost all of the XRF readings for lead are less than the LOD, comparisons cannot be conducted. Arsenic and chromium have detected measurements; however, correlation evaluations are limited since all of the values are low and close to the detection limits.

The results are similar to the July and August 2012 regression analysis showing poor correlation between sieved XRF/laboratory analysis based on the regression curves and r^2 values. The correlations are not comparable for these low concentrations likely due to the high amount of scatter associated with data at low concentrations.

3.10.1.3 Conclusions and Recommendations for XRF Correlation

Future correlation evaluations may need to be performed at locations where a broad range of lead concentrations are present in order to develop a correlation between XRF readings/laboratory results. In addition, future studies may compare XRF insitu measurements to sieved and dried soil measurements.

3.10.2 Field Screening Correlation Study for POLs

Thirty-six individual correlation samples were collected for POLs in AOCs C, D, and J. Each soil sample was screened with the UVOST system and analyzed by an analytical laboratory for DRO. Since the SiteLAB® fluorescence test kit did not arrive on site until mid-October 2012, only 26 of the 33 soil samples were screened with the SiteLAB® kit. The requested GRO calibration standards did not arrive with the fluorometer and so soil samples were analyzed only for DRO. Laboratory data for GRO were not considered in this correlation evaluation.

3.10.2.1 Background

Both the UVOST and SiteLAB system screen for POL contaminated soil by the use of LIF. Aromatic hydrocarbons, which include ring-shaped compounds such as benzene, naphthalene, benzo[a]pyrene, and many others, both excite and emit energy at specific wavelengths. Approximations can be made regarding the type and concentration of contamination by measuring the specific wavelength and intensity of this LIF.

The UVOST system produces measurements that show the concentration of contamination within soil as a percentage of a known RE. Therefore, the UVOST system does not produce a true concentration value such as found in laboratory analytical results. However, it has been found that the response is typically linear and proportional within a single fuel type released into homogenous soil. However, specific site conditions can affect the degree of fluorescence for equal concentration of fuel contamination. UVOST's response depends on "optically available" NAPL pressed against the sapphire window. Response tends to decreases as the particle size and soil color decreases. Tiny particles (high surface area) help "hide" the NAPL and dark soils help "sink" any resulting fluorescence. Additionally, some soils such as pumice, marine shells, and organic soils may add their own intrinsic fluorescence to the fluorescence generated by the POL.

Dakota Technologies reports that there has been as much as a 10-fold difference in response due solely to the site specific soil matrix conditions. Therefore, a correlation evaluation conducted on different types of fuels in site specific soils can then be used to determine the likely concentration values of the observed contamination specific to those fuels within soils having the local site characteristics.

It should be noted that the UVOST system has difficulties detecting high-PAH content NAPLs such as tars, bunker, and crude oil. These high-PAH content NAPLs have significant energy transfer and quenching between molecules that actually reduce their LIF at high concentrations.

The SiteLAB® system is also a fluorescence induced screening tool. Unlike the UVOST system, the SiteLAB® UV fluorescence test kits result in an actual concentration level for specific POL ranges in milligrams per kilogram (mg/kg) of soil. This screening tool can then be used, for example, to determine if backfill can be replaced immediately into test pits rather than leaving test pits open for the extended time required for laboratory analysis.

The SiteLAB® system provides a backup to the UVOST system in situations where high-PAH contamination may be present. The system avoids the quenching issue by diluting the heavier NAPLs within the carrier methanol solvent. The energy transfer between these heavy PAH molecules is minimized by the intervening methanol. The field team conducted limited testing of the comparability of the SiteLAB data to both UVOST fluorescence and to laboratory analytical data. The SiteLAB® fluorometer's response of each sample is measured by the instrument on a linear, multi-point calibration curve using certified standards sensitive to the wavelengths of interest. Samples were extracted in methanol solvent using disposable test kits and then placed into the analyzer for analysis, where the concentration was displayed in only a few seconds. Methanol blanks, as well as the standards, were run in batch as a QA/QC measure every 10 samples.

3.10.2.2 Soil Collection and Methodology for POL Correlation Study

Thirty-six samples were collected with the direct push drill rig and with a stainless steel hand auger from areas with various contamination levels from three individual site features (C-LT-002, D-TF-002, and J-SP-003). A GRO grab sample was collected for analytical laboratory analysis. The remaining soil was then homogenized on site. Following homogenization of the soil, approximately 100 grams (approximately ¼ cup) of homogenized soil was placed on the UVOST window. The UVOST system then collected a % fluorescence measurement of the soil in the *exsitu* measurement mode. The soil material screened by the UVOST was then placed directly in a sample jar for the analytical laboratory. This was repeated until the sample jar was full (about four measurements). The RPD between each of the UVOST readings on the individual 100 gram splits was calculated and did not exceed 25% within the same soil sample. In the few instances where the RPD did exceed 25%, new soil material was acquired and homogenized and the procedure was repeated.

Twenty-three soil samples were collected from AOCs C, D, and J for analysis using the SiteLAB® system. The sample soil was split into subsamples; one for UVOST and laboratory DRO analysis and one for SiteLAB® DRO analysis. The soil collected for SiteLAB® screening was homogenized and split into two additional subsamples. One subsample was homogenized further and tested with the SiteLAB®; the other subsample was sieved and tested with the SiteLAB®. These SiteLAB® result values were averaged together.

3.10.2.3 Results of the POL Correlation Study Evaluation

Thirty-six soil samples were collected for the correlation study. For each of the 36 samples, soil was collected, homogenized, and screened with the UVOST system in emulation mode. Soil with four UVOST readings (<25% RPD) was submitted for analytical laboratory analysis. Table 3-9 shows the results for the average UVOST %RE, laboratory DRO results and SiteLAB® screening DRO results. A regression analysis of all of the UVOST data points for all fuel and soil types compared to laboratory DRO analytical data shows a linear coefficient r^2 value of 0.31. These values are shown in Figure 3-14. However, a linear regression of concentrations less than 1,000 mg/kg (as illustrated in Figure 3-15) shows an r^2 value of 0.78. The importance of correlation becomes critical in this lower range where the data are used for helping to determine whether the concentrations of POLs at a specific site feature exceed the regulatory limits. It should be noted that the variability in higher concentrations and higher UVOST %RE values would not impact the decision of whether a site exceeded PALs or not. The evaluation of the correlation of analytical data with %RE for each of the investigated fuel types is described below.

Correlation Evaluation for Contamination at AOC J, Spill 003 (J-SP-003)

A total of 10 individual correlation samples were taken from site feature J-SP-003 near UVOST probe 12FMJSP003UV005. The concentration of DRO within the samples ranged from 2.9 mg/kg to 17,000 mg/kg. The GRO concentrations within the samples were low, with a maximum concentration of 3.3 mg/kg. However, without exception, the RRO concentrations were higher than DRO concentrations within samples from this release. The average RRO was over 130% of the DRO concentration, with some concentrations 3 to 4 times the DRO concentration. The waveform of fuel contamination observed with the UVOST at site feature J-SP-003 is shown in Figure 3-16.

The soil description, as recorded in the lithologic log, is:

- Well graded SAND (SW), compact, very dark grayish brown (10 YR 3/2) with obvious fuel staining, dry, fine to coarse SAND with trace amounts of sub angular to sub rounded GRAVEL.

The soil within this site feature was relatively homogenous throughout the soil column sampled.

The correlation coefficient for the UVOST %RE compared to laboratory data for a straight line trend is r^2=0.90. The %RE response within this fuel type is the lowest of the three investigated fuel types and site features. This lower response may be expected in dark colored finer grained soils with predominately heavy chain POLs. The correlation data are graphically plotted in Figure 3-17. It should be noted that the *insitu* LIF measurements for this fuel type were considerably higher than the *exsitu* measurements. For example, the UVOST measurement in UVOST boring 12FMJSP003UV005 within the 2- to 3-foot zone was a relatively consistent 6% RE. Sample 12FMJJSP003DT001 from this same zone had a laboratory measured DRO concentration of 7,600 mg/kg. Based upon the *insitu* measurement, it is likely that this fuel type is dramatically higher fluorescing in actual field conditions.

Correlation Evaluation for Contamination at AOC D, Transformer 2 (D-TF-002)

A total of 13 individual correlation samples were taken from site feature D-TF-002 near UVOST probe 12FMDTF002UV002. The concentration of DRO within the samples ranged from 29 mg/kg to 22,000 mg/kg. The GRO concentrations within the samples ranged from a low of 2.5 mg/kg to a maximum concentration of 19 mg/kg. RRO concentrations ranged from 10 mg/kg to 500 mg/kg within samples from this release. Typically, the GRO and RRO were present within the samples at levels 1 to 10% of the concentration of DRO. The waveform of fuel contamination observed with the UVOST at site feature D-TF-002 is shown in Figure 3-18.

The soil description, as recorded in the lithologic log, is:

- Well graded SAND with GRAVEL (SW), compact to dense, very dark grayish brown (10 YR 3/2), dry, mostly medium to very coarse angular to sub angular sand with trace amounts of fine sand, some angular to sub angular pumacious gravel.

The three points representing DRO concentrations of 19,000 mg/kg, 21,000 mg/kg, and 22,000 mg/kg plot abnormally low on the %RE scale (4.45, 3.17, and 5.25% RE, respectively) compared to other values. These three high concentrations of fuels appear to exhibit lower levels of %RE than a straight line correlation would have predicted. These higher values correlate much better when modeled with a polynomial trend line. This type of correlation trend is common with UVOST when measuring higher PAH fuels that exhibit energy transfer and fluorescence quenching. However, if these three outliers are excluded from the regression analysis, the straight line fit of all other points is r^2=0.77. The correlation data are graphically plotted in Figures 3-19 and 3-20.

Correlation Evaluation for Contamination at AOC C, Latrine 2 (C-LT-002)

A total of 13 individual correlation samples were taken from site feature C-LT-002 near UVOST probes 12FMCLT002UV001, 12FMCLT002UV002, 12FMCLT002UV016, and 12FMCLT002UV018. The concentration of DRO within the samples ranged from 5.3 mg/kg to 14,000 mg/kg. The GRO concentrations within the samples ranged from a low of 2 mg/kg to a maximum concentration of 320 mg/kg. RRO concentrations ranged from 12 mg/kg to 580 mg/kg within samples from this release. Typically, GRO was present within the samples at levels 1 to 10% of the concentration of DRO, while RRO concentrations were slightly higher at 10 to 20% of the DRO concentration. Samples were collected from multiple locations surrounding the feature. It is evident from the waveforms recorded by the UVOST that multiple release sources are present at this feature. The waveforms of fuel contamination observed with the UVOST at site feature C-LT-002 are shown in Figure 3-21.

The soil description, as recorded in the lithologic log, is:

- Well graded SAND (SW), compact to dense, dark yellowish brown (10 YR 4/4), damp, medium to fine- angular to sub-angular sand, little amounts of sub angular to sub rounded clasts of gravel (pumice), gravel color grades downward into light gray (10 YR 7/2) by 7 feet, size grades from medium to fine to very fine over the 7- to 9-foot zone.

It should also be noted that the soil column contained multiple 1- to 3-inch laminated zones of higher amounts of pumice.

The data plot rather linear with the exception of two points that exhibit abnormally high fluorescence as shown in Figure 3-22. Soil for one of these two elevated fluorescence points was collected from a shallow depth (2 feet bgs) near UVOST probe 12FMCLTOO2UV001 and may be influenced by root material. The other point was collected at a depth of 4 to 6 feet bgs near UVOST probe 12FMCLT002UV018, and therefore it is unlikely that surface root material could be the cause of this elevated LIF. Unlike the RI samples, the amount and size of pumice particles were not specifically recorded for each of the correlation sample points so it is unknown how they may affect these higher fluorescence values. Excluding these two outliers results in a rather linear plot of data, with a straight line correlation coefficient of r^2=0.68.

It is important to note that these two elevated points do exceed the PALs by one to two magnitudes, and therefore the higher than expected LIF does not cause a false field conclusion.

Use of Correlation Study Results in the Field

The purpose of the correlation evaluation is to determine if the field crew can make the proper real time decision about contamination during the investigation. An example of the real time use of the LIF data for sample collection and the resulting laboratory concentration values is the investigation at AOC C, Debris Feature 1 (C-DB-001). The field crew identified a zone of contamination within UVOST probe 12FMCDB001UV002 at a depth of 5.3 to 5.8 feet bgs. The UVOST log indicated a LIF value approximately 0.9% above the borehole *insitu* background for this interval. The sample collected from this interval resulted in a laboratory analyzed DRO concentration of 180 mg/kg, well below the PAL for DRO of 250 mg/kg.

Correlation Summary

The correlation evaluation was conducted in order to allow the field team and other stakeholders the ability to determine the presence of POLs within the subsurface that may exceed the PAL based upon LIF. The data indicate that the different released fuel types respond somewhat differently to the UVOST LIF. Additionally, soil parameters (i.e., particle size and color) as well as the presence or absence of modern or paleo vegetation affect the overall LIF response. However, the purpose of the UVOST is not to determine an exact contaminant concentration within the soil column but to predict if the soil contaminant concentrations are below or above the PALs. It was found during this study that using a threshold value of 1% LIF above the observed fluorescence background would be predictive of the contaminant concentrations in regards to the PALs. The data could be visualized as falling into four categories:

1. Low LIF with concentrations that fall below the PAL (True Negative),

2. Low LIF with concentrations that exceed the PAL (False Negative),

3. High LIF with concentrations that exceed the PAL (True Positive), or

4. High LIF with concentrations that fall below the PAL (False Positive).

The possibility of false negative screening is the outcome that has consequences to human health and the environment and therefore must be avoided. The most conservative approach would be to set the threshold level so low that numerous false positives would be generated that would require that every depth within every borehole be sampled. This ultra-conservative approach would ensure that no false negatives are generated. However, such a conservative approach results in the expenditure of needless time and funds. Therefore, the key to this correlation evaluation is determine a threshold value that generates only true negatives and true positives while minimizing or even eliminating all false positives and negatives. A review of the LIF data reveals that a LIF value of 1% above the background meets that criterion. At a threshold value 1% above the exsitu soil measured background the correlation data generated only true positives and true negatives. This value is further supported by the results of actual laboratory-based sampling and analysis near this LIF, such as at site feature C-DB-001 (LIF slightly below threshold and DRO concentration below PAL). Therefore, a threshold value for triggering investigation of contamination zones will be set at a conservative LIF value of 1% above the borehole *insitu* background DRO.

Exsitu Versus Insitu Measurements

The comparison of the exsitu measurements used in the correlation sampling to *insitu* borehole measurements is complicated by the inability to directly determine if the soil measured prior to removal from the subsurface is the exact soil measured after removal. However, the data from *exsitu* versus *insitu* measurements appears to indicate that exsitu measurements may be systematically lower than the *insitu* measurements. This determination is based upon comparing *insitu* borehole measurements to the nearest *exsitu* measurements made during the correlation evaluation. In almost every case of directly adjacent measurements, the actual *insitu* measurement was more than 1.5 times the resulting exsitu measurement. This would tend to indicate that the 1% *exsitu* measurement threshold is in reality a 1.5% threshold when measured with down borehole LIF. This is also consistent with previous correlation evaluations conducted by the UVOST manufacturer (Dakota Technologies, Inc.). Their evaluations show that *insitu* data nearly always have a slightly higher response than *exsitu* bench testing. Therefore, the correlation curves developed during *exsitu* bench testing will be conservative and an equal response *insitu* will represent a true concentration value less than the concentration value determined by *exsitu* testing.

3.11 Computation of Contaminated Soil Volumes

The volume of soil exceeding the PALs at site features was computed using the spatial modeling capabilities found within the ArcGIS version 10.1 software. Data input into the model was the effective LIF measurements for all of the UVOST probe locations at each site figure. Supplemental points representing samples that indicated that the soil was below PALs were also included to more accurately limit the spatial extent where this data were available. Contouring of the area of contamination was then undertaken by interpolating UVOST points to contours of LIF values through the inverse distance weighted spatial modeling. Variable parameters were set as follows:

- Output cell size was left as default (1.546337 10-6),
- Exponent of distance was set to a power of 4, and
- Search radius was set to variable (default) utilizing 20 points.

The volume of the soil was then computed by multiplying the thickness of contamination by the computed square footage of the areal extent of the feature that likely exceeded PALs.

3.12 Risk Evaluation

A cumulative human health risk evaluation was performed following the ADEC Risk Assessment Procedures Manual (ADEC, 2009b) and the ADEC Method 3 Cumulative Risk Guidance (ADEC, 2008a). Additionally, the surface soils (0 to 2 feet bgs) data were screened against the ADEC Ecological Risk-based Screening Concentrations (ERBSCs).

The human health risk evaluation was performed for the soils and groundwater. The soils were not separated into surface soil and subsurface soil because human exposure to either media was considered to be possible under the unrestricted use.

The ecological screening was limited to the soils because groundwater is not a likely media for ecological exposure. Groundwater does not daylight on site; therefore, potential surface water exposure was ruled out. Surface water data were not collected during the 2012 RI.

The site data were re-screened for the purpose of the cumulative risk evaluation. The COPCs were identified by comparing the site data against the lower one-tenth of the ingestion/dermal cleanup level or one-tenth of the inhalation cleanup level (ADEC-CL). The ADEC-CLs did not exist for several of the project identified chemicals. For these chemicals, the risk-based concentrations were calculated using the methodology in the ADEC Cleanup Levels Guidance (ADEC, 2008b), and the latest EPA toxicity values (November 2012) available in the EPA's Integrated Risk Information System (IRIS) and the RSL tables (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm). Table 3-10 presents the calculated cleanup levels for chemicals not included on ADEC's tables. Note that the ADEC_CLs and risk-based values are based on the carcinogenic risk threshold of 1×10^{-5} and hazard index (HI) of 1. Taking one-tenth of these values implies that the carcinogenic risk threshold of 1×10^{-6} and HI of 0.1 were used in identifying the COPCs. This is a standard practice in risk assessments.

3.12.1 Investigation Activities and Data Groupings

Surface soil, subsurface soil, and groundwater samples were collected as part of the RI. For the purpose of the risk evaluation, no grouping of the samples was performed. The soil samples were kept together as soils regardless of the sample depths. The only grouping of the samples was by the AOCs.

The groundwater samples are comprised of the samples collected from the monitoring wells installed and collected as part of the RI.

The soil and groundwater samples were analyzed for organic and inorganic constituents using EPA- and ADEC-approved methods. Data were validated using the methodology presented in the project Work Plan. The rejected data were not used in the risk evaluation. The unqualified and estimated detected data were used at the reported values regardless of the bias in the results, if any. The QC evaluation and data validation results are summarized in the CDQR in Appendix G.

3.12.2 Identification of Human Health Chemicals of Concern

The entire 2012 RI dataset was screened against one-tenth of the ADEC-CL or the ADEC-CL-equivalent risk-based values (termed risk screening value to differentiate from the PALs used in the nature and extent delineation) to initially identify the site-wide COPCs. Table 3-11 presents the site-wide chemicals that exceeded the risk screening values in soil and in groundwater. A total of 15 chemicals (nine organics and six metals) exceeded the risk screening values in soils, while 17 chemicals (four organics and 13 metals) exceeded the risk-based values in groundwater. These COPCs were further evaluated on an AOC basis to discern if there were any contaminant trends in the AOCs. Table 3-12 presents the summary statistics by AOCs, including the number of detects and the number of exceedances of the risk-based PALs.

As shown in Table 3-12, the AOC-specific detection and exceedance trends are narrower than the site-wide trend, and the vast majority of the exceedances are for the metals. With the exception of the total petroleum fractions, there are only one to two exceedances of the organic compounds in the AOC soils. The maximum detected concentrations are relatively low. These observations indicate localized contamination, if any. Of the total 487 metal exceedances in soil, 470 exceedances are accounted for by arsenic, cobalt, and iron. Chromium, lead, and vanadium are the other metals with sporadic exceedances.

Table 3-12 also includes the metal background upper tolerance limits (UTLs) in soil developed for the Air Force RI. Only nine of the 487 exceedances are above the background UTL (1 lead, 6 arsenic, and 2 chromium exceedances). Cobalt, iron, and vanadium did not exceed the background. The low rate of background exceedances indicate that there are no significant releases of the metals into the AOC soils and the nine exceedances may be natural outliers.

Regarding arsenic and metals in general, ADEC recognizes in the "Arsenic in Soil" Technical Memorandum (ADEC, 2009c) that arsenic and other metals occur naturally at variable concentrations. The metals cleanup or institutional controls are recommended if the source of the metals release is anthropogenic, or if the site activities caused an alteration of the natural source resulting in the metals release. The site history does not indicate the use of anthropogenic sources of the arsenic, chromium, and lead. Further, five of the six exceedances of arsenic are noted at depths ranging from 5 feet to 15 feet bgs. Only one exceedance occurred at the 1.5- to 2-foot depth at a concentration of 7.2 mg/kg, barely above the background concentration of 7.05 mg/kg. All other detections of arsenic in the top 2 feet of soil were below the background levels. Also, there is no plausible mechanism that can justify the migration of arsenic from surface to depths of 15 feet. These observations point to an absence of arsenic source, and to the possibility that the higher arsenic concentrations at depths are natural variations. Similarly, total chromium exceeded the PAL in AOC C at site feature C-DB-0001 (in the primary and the field duplicate sample) at a depth of 4 to 8 feet bgs. When this location was resampled for hexavalent chromium, it was not detected above the hexavalent chromium PAL. A source of chromium is not indicated by this observation. Finally, lead did exceed the background value in the surface soil at an AOC J Warehouse location (J-WH-002-DT005). The lead exceedance does not coexist with the petroleum hydrocarbons detected at the warehouse locations. It is possible that lead is not fuel-related, and metallic lead fragments may have been dispersed in the soil given the function of the warehouse.

All COPCs, including the metal exceedances discussed above, were carried forward in the cumulative risk evaluation using the ADEC Method 3 calculator. The ADEC default residential exposure parameters for the "Under 40-inch Zone" were used.

3.12.3 Cumulative Human Health Risk Calculations

No statistical calculations were performed. The site-wide maximum detected concentrations were used initially in the cumulative risk evaluation. The objective was to calculate the risks for all COPCs in a single effort and then back calculate the carcinogenic and noncarcinogenic risk-based concentrations (RBCs) using the input concentrations and the risks calculated by the Method 3 calculator. The risk-based concentrations can then be used with the AOC-specific chemicals and concentrations to calculate the AOC-specific risks. The ADEC criteria for acceptable risk are 1×10^{-5} for carcinogens and 1 for noncarcinogens. These criteria were used in identifying the chemicals, media, and AOCs with potential risk concerns. The ADEC carcinogenic risk criterion of 1×10^{-5} is conservative compared to the range of 1×10^{-6} to 1×10^{-4} used in CERCLA.

Table 3-13 presents the site-wide maximum concentrations that were used in the ADEC's Method 3 and Cumulative Risk Calculator (http://www.dec.alaska.gov/applications/spar/webcalc/dsp_scenSelect.asp) for cumulative risk calculations. The table also shows the pathway-specific and total risks for the site-wide maximum concentrations. The two rightmost columns of Table 3-13 present the carcinogenic and noncarcinogenic RBCs (C-RBC and NC-RBC, respectively) calculated from the concentrations and the total risks.

The RBCs were used in the calculation of the AOC-specific risks for the AOC maximum concentrations. Table 3-14 presents the AOC-specific COPCs that exceeded the risk screening values, the maximum detected concentrations for the COPCS, and the background soil concentrations. The maximum concentrations were divided by the C-RBCs and NC-RBCs to yield the carcinogenic and noncarcinogenic risks for each COPC. The chemical risks were then added for the soil and groundwater media and the risks were summed for the cumulative risks for each AOC.

Table 3-15 presents the chemical-, media-, and AOC-specific risks. The soil and groundwater risks are presented for all AOCs; however, the groundwater risks are not discussed further. A few observations are made with respect to groundwater:

1. Practically all of the groundwater risks arise from metals,

2. Metals are ruled out as sources of contamination in the AOC soils, and

3. Background groundwater data are not available to determine if the site groundwater metal concentrations are statistically elevated in comparison to the background concentrations. However, in keeping with the ADEC Technical Memorandum on arsenic in soil (ADEC, 2009c), it is postulated that in the absence of anthropogenic sources of metals, background samples are not necessary and the metals in the groundwater are considered to be naturally-occurring.

Other than metals, petroleum fuel fractions were found in groundwater in AOCs C and J. The soils data for these AOCs indicate a petroleum release. Because there are no RBCs for the petroleum fractions, a comparison with the ADEC cleanup criteria is more appropriate.

3.12.4 Protection of Groundwater Levels and Final Project Action Levels

Table 3-16 presents the PALs based on the ADEC cleanup criteria. Protection of groundwater from leaching of the contamination is an indirect pathway that is not addressed in the risk calculations. However, it is essential that a receptor be protected from direct exposure as well as the indirect exposure. Table 3-16 includes the protection of groundwater criteria. The eventual PAL is the lower of the direct inhalation and the protection of groundwater levels. For the GRO and DRO fractions, protection of groundwater is more critical than the direct exposure pathways, while for the RRO fraction, protection from ingestion and dermal contact is more important.

Table 3-17 presents the petroleum fraction data that exceed the final PALs.

3.12.5 Ecological Screening

The results of soil samples collected up to a depth of 2 feet bgs were screened against the ADEC ERBSCs. Table 3-18 presents the summary statistics for all chemicals against screening criteria in all AOCs. Only metals exceeded the criteria. As discussed previously, the metals are believed to be naturally occurring. Therefore, there are no incremental ecological risks above those existing naturally. A further evaluation of the ecological risks is not necessary.

The results of soil samples collected up to a depth of 2 feet bgs were screened against the ADEC ERBSCs. Table 6-9 presents the summary statistics for chemicals exceeding the screening criteria. Only metals exceeded the criteria. As discussed previously, the metals are believed to be naturally occurring. Therefore, there are no incremental ecological risks above those existing naturally.

However, in accordance with the ADEC guidance, the ecological scoping forms have been completed for all 10 AOCs and included in Appendix L. While the ecological screening presented above is strictly in terms of observed concentration and the threshold values, the scoping forms evaluate more realistically the specific features of the AOCs, receptors, exposure mechanisms, habitat properties and chemical properties to determine if further evaluations or investigations may be necessary. Based on this more specific assessment, further ecological evaluation may be necessary for the five AOCs (AOC C, AOC D, AOC E, AOC G, AOC J and AOC K). A common ecological CSM for these five AOCs is presented in Appendix L. The course for these AOCs would be determined in consultation with the Triad Team. For the other four AOCs (AOC F, AOC H, AOC I and AOC L), further ecological evaluation is not indicated.

4. RESULTS OF THE INVESTIGATION

The 2012 RI at Fort Morrow was conducted in only 10 of the 13 AOCs; C through L. The results of the RI are presented in this section on an AOC by AOC basis. An updated CSM and an overview of the screening and sampling conducted in each AOC are described along with a discussion of the historical military activities. Given the large number of site features investigated, only those site features within each AOC where suspected contamination was identified by either screening (UVOST, XRF, radiological) or sampling and laboratory analysis are discussed below.

Maps with the actual screening and sampling locations are provided in Appendix M (included as Volume II). Photographs of each feature are provided in Appendix N. Data tables presenting detected compounds are provided in Appendix A and full data tables showing all results are provided in Appendix O.

4.1 Site Feature Evaluation

The field crew visited and evaluated every site feature identified in the Work Plan in AOCs C through L. The crew photographed the feature and surveyed the perimeter with a GPS unit. The field crew then laid out grids at the feature if it was selected for screening. Several obvious additional site features were located during the process of site evaluation. The field crew added these features to the work plan listing. An attempt was made to determine what type of feature each new site represented. The new features were compared to the previously listed features within that specific AOC and assigned a site feature type consistent with their appearance. Additionally, the field crew found that four features within AOC F were no longer present due to the head-ward erosion of the Bering Sea beach. The number of features deleted and added by screening frequency category is included as Table 4-1. The table also shows the number of screening and sampling locations resulting from the addition and subtraction of these features.

Table 4-2 presents the number of site features that North Wind actually screened and sampled during this phase of the RI. It should be noted that the single missing sample location in both AOC E and AOC F were due to site features that contained significant amounts of buried metal (as identified by the geophysical survey conducted in the area of those site features) that could therefore not be sampled.

4.2 AOC C

The field investigation in AOC C occurred from June 20, 2012 through July 24, 2012. Eighty-three site features were investigated in AOC C (see Table 4-2). Two site features were reclassified as latrine features and not quarters/barracks based on the presence of drain pipes and a concrete foundation. One site feature was added as an unknown feature and one was added as a pipeline feature. During the field identification of site features, it was noted that the physical position and location of each site feature was shifted to the south and west approximately 100 feet from the locations and positions shown on the aerial photography based maps included in the Work Plan. Fifty site features were screened with UVOST technology and soil samples were collected at 39 site features (Table 4-2). Section 4.2.4 provides a summary of the variances from the Work Plan. Four groundwater monitoring wells and one piezometer were installed in AOC C. The history of AOC C, an updated CSM, and a summary of the results of the investigation in AOC C are provided below. Figures with actual screening and sampling locations and the locations of the geophysical surveys and installed groundwater monitoring wells and piezometers, as well as the location of detected groundwater contamination, are provided in Appendix M.

4.2.1 Historical Use of AOC C Area

The 205th Station Hospital was located to the east of the airfield in what is AOC C. The unit was composed of approximately 11 officers and 73 enlisted men (Seid, 1944). In the approximately 635 acres that make up AOC C, there were multiple Quonset hut hospital wards, an x-ray room, two mess halls, several Quonset huts for quarters, and two latrines. The area also had a separate power generation structure. The two latrine features were initially identified in the work plan as quarters but the field team found them to be consistent with blueprints for latrines, as found in TM 5-280, Construction in the Theater of Operations (War Department, 1944). Historical photographs of the area show abundant drums of fuel stored within the AOC.

4.2.2 Conceptual Site Model

The CSM forms for AOC C have been updated based on the 2012 screening and sampling results. The CSM graphic form (Figure 4-1) and figures showing potential release mechanisms and potential receptors (Figures 4-2 and 4-3) are provided in the Figures section that follows the text within this RI report, and the CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC C included USTs, aboveground storage tanks (ASTs), fuel dispensers, drums, vehicles, landfills, and latrine plumbing. The potential release mechanisms at AOC C included spills, leaks, and direct discharge. The potentially impacted media in AOC C included surface soil, subsurface soil, air, groundwater, and biota.

Direct contact by incidental soil ingestion is a complete pathway at AOC C because contaminants are present in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because contaminants that can permeate the skin were detected in the soil between 0 and 15 feet bgs. Ingestion of groundwater is a complete exposure pathway because contaminants were detected in the groundwater and/or detected contaminants in the soil can be expected to migrate to groundwater in the future. Ingestion of surface water is an incomplete exposure pathway. Surface water was not sampled because it was determined that there were no bodies of water that met the approved Work Plan definition of a "significant body of more than 100 square feet located within 50 feet downgradient of contaminated groundwater" (North Wind, 2012).

Contamination is present where it can potentially be taken up by biota, and is in an area that is used or could be used for hunting and harvesting; therefore, ingestion of wild foods is a complete exposure pathway. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum compounds are present in the surface soil. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC C because petroleum and volatile contaminants were detected within 30 feet of a potential future building site.

4.2.3 Summary of the Screening and Sampling Activities in AOC C

Table 4-3 provides a summary of the screening and sampling activities conducted in AOC C. The site features that had contaminants detected by the UVOST system or XRF monitor and/or detections in the analytical data above the project action level (PAL) are discussed in more detail in Sections 4.2.7 and 4.2.8. Figures with the locations of the site features discussed and that show the location of detected soil and groundwater contaminants are provided on figures in Appendix M. Deviations to the technical approach in the Work Plan for AOC C are discussed in Section 4.2.4.

4.2.4 Deviations to the Work Plan

During the course of the investigation in AOC C, 23 variances from the Work Plan were identified and documented as deviations. A complete listing of the deviations is provided in Table 4-4.

There were 23 variances to the work plan in AOC C. Two Quarters (QT) site features were identified in the field as being Latrines (LT). These two site features were renamed as LT site features. The geophysical survey determined the presence of buried metal debris at two site features originally selected for screening and sampling in the work plan. These site features were not screened or sampled. Three site features were newly identified in AOC C during the course of field activities. Nine site features were inaccessible to the drill rig. Five of these were not screened or sampled. Four of the inaccessible site features were screened and sampled using the hand auger soil collection method. Two site features not selected for screening or sampling in the work plan were screened and sampled as alternatives to two site features which were inaccessible to the drill rig. One Ground Scar (GS) site feature was determined to be a road. One GS site feature listed as an alternative site feature for screening and sampling in the work plan was determined to be bermed on three sides and so was screened and sampled. Buried pipe was discovered in one GS site feature. The pipe originated in Mess Hall 001. This site feature was screened and sampled. One GS site feature was thought to be a drain field for the newly identified Pipeline (PL) site feature.

4.2.5 UVOST POL Screening Results

Fifty site features were screened using UVOST technology in AOC C. A total of 327 UVOST boreholes were drilled totaling 5,273 feet drilled; 52 feet in 12 boreholes were drilled with stainless steel hand augers and the remaining 5,221 feet drilled with a direct push drill rig.

As shown in Table 4-3, of the 50 site features screened in AOC C, UVOST screening identified potential contamination at nine site features. Details of the investigation of each of these nine site features are described below. In addition to the discussion of the UVOST screening, the detected results of GRO, DRO, and RRO at these site features are discussed as well, regardless of whether they were above or below their respective PAL. All detected analytes above the PALs are discussed in Section 4.2.7.

4.2.5.1 AOC C – Debris 001 (C-DB-001)

Eight screening boreholes were drilled at this debris related site feature. The boreholes were identified as 12FMCDB001UV001 through UV008. Figure 4-4 shows the UVOST screening borehole log for 12FMCDB001UV001. From 0 to 0.4 feet bgs, there is noise due to the UVOST recording data before the window on the drill tip is covered with soil. From 0.4 to 2.9 feet bgs, a waveform consistent with soil and subsurface soil was recorded. From 2.9 to 3.3 feet bgs, the waveform recorded is consistent with a potential fuel signature; however, as the %RE is small (1.3% RE maximum or less than 1% above *insitu* background). Based on the results of the POL correlation study, it is unlikely that this potential contamination would be above regulatory levels.

Figure 4-5 shows the UVOST screening borehole log for 12FMCDB001UV002. The borehole log shows surface vegetation at 0 to 2.8 feet bgs. From 2.8 to 3.4 feet bgs, the waveform exhibits LIF values above background with a peak of 2.5% fluorescence consistent with a potential fuel signature in the 3.0- to 3.2-foot depth; this same waveform again appears from 5.0 to 5.8 feet bgs with a consistent % fluorescence of 1.3%. There is a clean subsurface soil waveform at 3.4 to 5.0 feet bgs between the two fuel type waveforms. From 5.8 to 16.4 feet bgs, a waveform consistent with uncontaminated soil was recorded. The results of the correlation study conducted, as discussed in Section 3.11, indicated that suspected contamination at these low %RE values would likely be below regulatory levels. The results of the laboratory analysis of these soil samples confirmed that COPCs were below regulatory levels.

The field crew determined that the very thin lens of contamination in the 3.0 to 3.2 feet depth range was of insufficient quantity to provide the volume required for full suite analysis. Therefore, the larger thickness of contamination near the 5-foot depth was selected for sampling. One soil sample was collected for the full suite analysis from 4.5 to 5.5 feet bgs at this site feature (12FMCDB001DT001) near screening location UV002. The results of the POL constituents of this sample show that GRO was present at 1.5 mg/kg (PAL= 300 mg/kg), DRO at 180 mg/kg (PAL=250 mg/kg), and RRO at 520 mg/kg (PAL=10,000 mg/kg). The locations of the screening boreholes and sample collection locations, as well as the detected contaminants for this site feature, are shown on the maps in Appendix M. See Appendix A for a summary of detected sample results, and Section 4.2.7 for a summary of detections in soil above the PALs.

4.2.5.2 AOC C – Ground Scar 001 (C-GS-001)

The field team evaluated this ground scar and found it to be significantly different than other ground scars in that this feature was surrounded by a soil berm, perhaps indicating the presence of stored fuel drums. Thirty-three screening boreholes were drilled at this site feature with the direct push drill rig. The UVOST screening borehole locations were identified as 12FMCGS001UV001 through UV033. The fifteenth borehole log (UV015) for C-GS-001 shows a potential fuel signature from 0 to 3 feet bgs. Figure 4-6 shows the UVOST screening borehole log for UV015. From 0 to 3 feet bgs, there is a waveform consistent with a possible fuel contamination with a maximum percent fluorescence of 2.2% within the 3 to 4 feet bgs range. The UVOST log from 4 to 14 feet bgs is less than 1% fluorescence. The UVOST log from 14 to 14.8 feet bgs shows a slight increase in fluorescence due to the paleosol layer. This potential fuel signature is below the 1.5% insitu LIF threshold and therefore this small area of possible contamination is likely below the PALs.

One soil sample was collected for full suite analysis (12FMCGS001DT001) from 12 to 14 feet bgs midway between UVOST probes UV014 and UV025, and three samples were collected for fuels only (POL) analysis (12FMCGS001DT002 from 2 to 4 feet bgs near UVOST probe UV013, 12FMCGS001DT003 from 8 to 11 feet bgs near UVOST probe UV030 and 12FMCGS001DT004 from 2 to 4 feet bgs near UVOST probe UV016) at this site feature. The results of the POL analysis show that GRO was detected at a range of 1.5 to 4 mg/kg (PAL= 300 mg/kg), DRO was detected at concentrations ranging from 1.6 to 3.8 mg/kg (PAL= 250 mg/kg), and RRO was qualified as not detected. See Figure C-1 in Appendix M for soil screening and sampling locations, including a listing of detected contaminants. See Appendix A for a summary of detected soil sample results, and Section 4.2.7 for a summary of soil detections above the PALs.

4.2.5.3 AOC C – Ground Scar 004 (C-GS-004)

The field crew investigated this site feature and found that this feature was connected to other features within AOC C by what may have been a steel wire wrapped wood stave pipe. Therefore, it may be assumed that this linear trench feature was the outfall area for a drainage pipeline. One UVOST screening borehole was drilled with the direct push drill rig and three screening boreholes were drilled with the stainless steel hand auger at this site feature. The screening locations are identified as 12FMCGS004UV001 through UV004. Soil collected for screening using the hand auger was collected in six 1-foot intervals, placed into re-sealable bags and then screened with the UVOST system in emulation mode. Figure 4-7 shows the UVOST screening borehole log for screening location 12FMCGS004UV004. From 0 to 4 feet bgs, the waveform is consistent with uncontaminated soil. From 4 to 6 feet bgs, the waveform is consistent with a possible fuel type waveform; however, the soil had no odor or sheen to it. The UVOST waveform has a somewhat shorter fluorescence duration in each of the channels than a typical fuel signature. This may indicate that the material is somewhat influenced by other vegetative or organic matter. The LIF emulation measurement in question was made from soil collected directly beneath the inferred depth of the drainage outfall wood stave pipe and may have been influenced by other organic material (sewage). One soil sample (12FMCGS004DT001) was collected for full suite near screening location UV001 from 4 to 6 feet bgs. GRO was detected at 0.9 mg/kg (PAL= 300 mg/kg), DRO was detected at 2.2 mg/kg (PAL=250 mg/kg), and RRO was qualified as not detected in this soil sample. See Figure C-1 in Appendix M for soil screening and sampling locations, including a listing of detected contaminants. See Appendix A for a summary of detected sample results, and Section 4.27 for a summary of detections above the PALs.

It may be advantageous to the feature characterization to collect a sample of material from directly below the suspected sewage outfall near UV004. Data from a soil sample at this location would unambiguously determine if the elevated LIF is associated with fuels or with other organic materials present in outfall.

4.2.5.4 AOC C – Latrine 002 (C-LT-002)

This feature was identified as a quarters site feature (C-QT-024) in the Work Plan based on aerial photography and limited historical data. Upon closer inspection, it became evident this site feature was actually a latrine due to the presence of several drain holes and the configuration of the concrete foundation (Figures 4-8 and 4-9). Four screening locations were initially laid out at this site feature. Suspected contamination was detected in the first screening borehole drilled, and so a number of step-out boreholes were drilled. A total of 35 screening boreholes plus a butterfly borehole were drilled at this feature. The UVOST screening borehole locations were identified as 12FMCLT002UV001 through UV035. A butterfly hole (BF) is a duplicate borehole drilled a distance of a few inches to a couple of feet from the original borehole. They are identified as the original screening borehole ID number with an additional “BF” suffix (e.g., 12FMCLT002UV001BF). Butterfly holes were drilled to determine the extent heterogeneity of subsurface LIF anomalies detected with the UVOST. The heterogeneity of suspected contamination, strong %RE due to vegetation matter, or any other LIF anomaly can be determined by drilling multiple screening boreholes in close proximity.

Figure 4-10 shows the UVOST screening borehole log for UV001. From 0 to 4 feet bgs, there is a waveform indicative of clean subsurface soil; from 4 to 9.5 feet bgs, the waveform is typical of a fuel type waveform. From 9.5 to 12.8 feet bgs, the profile of the screening waveform returns to clean subsurface soil; from 12.9 to 16.3 feet bgs, the waveform again changes, indicating potential subsurface soil contamination. The contamination abruptly stops at 16 feet bgs and the waveform is once again typical of clean subsurface soil until the total depth of the borehole at 20 feet bgs. The waveform seen in this borehole is consistent with a weathered diesel fuel type waveform. A butterfly screening borehole (UV001BF) was drilled 1 foot to the west of the original screening borehole (UV001) and suspected contamination was detected at the same depth as in UVOST probe UV001 (see Figure 4-11 for the butterfly plot of boreholes UV001 and UV001BF). It should be noted that the borehole number for the butterfly, as shown on Figure 4-11, was truncated by the UVOST software and should have an “F” at the end.

A second area of suspected contamination with a different wave form was detected at the second screening borehole location drilled, UV002, approximately 35-feet west of UV001. This waveform appears blue in color and is dominated by reflectance in the 350 nanometer channel, indicating the contamination is primarily composed of lighter weight, shorter chained PAHs. This second type of suspected contamination was detected at 2.5 to 6 feet bgs. Figure 4-12 shows the UVOST screening borehole log for UV002. From 0 to 0.4 feet bgs, there is interference in the log, likely the result of the drill operator initiating the data logger before the UVOST window was at ground level. Around 1.1 feet bgs, the waveform appears consistent with fuel contamination, the % fluorescence increases and peaks at 4.2% at 5.6 feet bgs. The contamination continues from the peak at 5.6 feet bgs to 7.8 feet bgs. Below this suspected contamination there is subsurface paleosol fluorescence detected at 7.8 to 12.4 feet bgs. From 12.4 feet bgs to the total depth of the borehole at 19.8 feet bgs, there is the waveform signature indicative of clean subsurface soil.

A third area of suspected contamination was located at UV008 in the south central portion of the feature, approximately 45 feet south of UV001. The waveform detected at this location is consistent with a fuel type waveform. Figure 4-13 shows the UVOST screening borehole log for UV008. From 0 to 0.2 feet bgs, there is some interference, likely the result of the drill operator initiating the data logger before the UVOST window was in contact with the ground. The log shows a waveform indicative of uncontaminated soil from 0.3 to 3.1 feet bgs. At 3.2 feet bgs, the waveform becomes typical of a fuel type waveform and peaks at a maximum % fluorescence of 11.7%. The % fluorescence decreases dramatically at 7.1 feet bgs, though the fuel type waveform is present at a depth of 14.4 feet bgs. At 14.4 feet bgs, the waveform looks like typical subsurface soil fluorescence until the total depth of the screening borehole at 20.1 feet bgs. It is likely that this contamination is connected to the contamination found at probe location UV001.

Screening location UV018 was drilled 28 feet to the southeast of UV008 to delineate the extent of subsurface contamination. Contamination was detected at this screening borehole. Figure 4-14 shows the UVOST screening borehole log for UV018. From 0 to 1.5 feet, the waveform is consistent with fluorescence of surface vegetation. At 1.6 to 12 feet bgs, the waveform is consistent with a fuel type waveform and the % fluorescence peaks at 15.7%. From 12.1 to 19.9 feet bgs, the waveform is consistent with uncontaminated subsurface soil. Again, this contamination is consistent in waveform and analytical data with contamination located at UV001 and UV008. The contamination delineated by all other UVOST probes at this location with the exception of UV002 are consistent with diesel or heating fuel and appear to represent a single contiguous zone of contamination.

A fuel type waveform was also detected at screening borehole 12FMCLT002UV019 (Figure 4-15) from 1.8 to 2.3 feet bgs and again at 5.4 to 6.5 feet bgs, with a maximum RE of 1.0% in those depths. The waveform then indicates the presence of subsurface paleosol at 6.5 to 9.6 feet bgs and then uncontaminated subsurface soil below that to a depth of 19.6 feet bgs. Screening borehole UV019 is located 22 feet south of borehole UV018. See Appendix E for the UVOST screening borehole log 12FMCLT002UV019. Based on the results of the UVOST correlation study, it is likely that this potential contamination is below regulatory levels.

A potential fuel type waveform was detected in screening borehole 12FMCLT002UV021 (Figure 4-16) at 5.5 to 6.5 feet bgs; however, the peak in % fluorescence is small (0.9%). This potential fuel, indicated on the UVOST, is in an outer step out borehole. Based on the results of the UVOST correlation study, it is likely that this potential contamination is below the PALs. This UVOST probe likely indicates that the contamination is still present at this lateral extent, but has dropped in concentration below the PALs. See Appendix E for the UVOST screening borehole log 12FMCLT002UV021. This borehole is located 46.7 feet to the southeast from screening borehole UV018.

Potential contamination was indicated by the UVOST with small peaks but distinctive fuel type waveforms at three of the outer step out boreholes drilled at this site feature. These boreholes include UV026 (6.4 to 6.7 feet bgs), UV034 (2 to 3.5 feet bgs), and UV035 (0.5 to 4 feet bgs and 8 to 8.5 feet bgs). Based on the results of the UVOST correlation study (see Section 3.10 for details), it is likely that contamination in these boreholes is below regulatory levels.

Step out screening points were drilled consistent with the 20-foot grid pattern laid out for this feature. Upon first review of the boring logs for screening boreholes UV021 and UV034, there did not appear to be a fuel type waveform; after second review of these two borehole logs, it does appear that there are areas of waveforms consistent with fuel type waveforms. However, since the % fluorescence is so small (< 1.8%), it is unlikely that any subsurface contamination would be above regulatory levels. See Appendix M for screening locations at this site feature.

The maximum effective LIF was computed for all UVOST probes in the area of site feature C-LT-002 and are plotted on Figure 4-17. The elevated LIF measurements that were taken within the subsurface paleosol or the current surface vegetation were excluded from the maximum values. A data analysis of LIF measurements was also conducted on each 1-foot increment within the UVOST borings. These average effective LIF values by 1-foot increments were then plotted as subsurface "slices" under the feature. These average effective LIF values at specific depths are shown in Figure 4-18. A transect through selected UVOST boreholes is also included as Figure 4-19.

The location of samples were determined to provide a lateral distribution of samples over the area on contamination as well as investigating the distribution of contaminant concentrations with depth. One sample for full suite analysis (12FMCLT002DT001) was collected near UV001/UV001BF at 4 to 6 feet bgs. The results of the POL portion of this sample show that GRO was detected at 59 mg/kg (PAL=300 mg/kg), DRO was detected at a concentration of 1,900 mg/kg (PAL = 250 mg/kg), and RRO was qualified as not detected. Three additional samples for POL suite analysis (12FMCLT002DT002, 12FMCLT002DT003 and 12FMCLT002DT004) were also collected at this specific site feature. One POL suite sample (12FMCLT002DT002) was collected from the same borehole as DT001 near screening borehole UV001/UV001BF but at a depth of 14 to 16 feet bgs. GRO was detected at 150 mg/kg, DRO was detected at 10,000 mg/kg, and RRO was qualified as not detected. Another POL suite sample (12FMCLT002DT003) was collected near screening borehole UV018 at a depth of 4 to 6 feet bgs. GRO was detected at 1.9 mg/kg, DRO was detected at 2,600 mg/kg, and RRO was detected at 260 mg/kg. The last POL suite sample (12FMCLT002DT004) was collected near screening borehole UV008 at a depth of 4 to 6 feet bgs. In this sample, GRO was detected at 2.7 mg/kg, DRO was detected at 2,300 mg/kg, and RRO was detected at 260 mg/kg. The location of the screening boreholes, the sample collection locations, along with a listing of detected contaminants are shown on Figure C-1 in Appendix M. Appendix A provides a summary table of soil sample results exceeding project action limits and Section 4.2.7 includes a summary of detections in soil above the PALs.

The volume of soil exceeding the PALs at this site feature was computed utilizing the spatial modeling capabilities found within the ArcGIS version 10.1 software. Data input into the model was the effective LIF measurements for all of the UVOST probe locations. Supplemental points representing samples that indicated that the soil was below PALs were also included to more accurately limit the spatial extent. Contouring of the area of contamination was undertaken by interpolating UVOST points to contours of LIF values through the inverse distance weighted spatial modeling. Variable parameters were set as follows:

- Output cell size was left as default (1.546337 10^{-6}),
- Exponent of distance was set to a power of 4, and
- Search radius was set to variable (default) utilizing 20 points.

The volume of the soil was then computed by multiplying the thickness of contamination by the computed square footage of the areal extent of the feature that exceeded 1.5 %RE above the insitu background of the borehole. The volume of soil computed through this method is 832 cubic yards. The outline of the contaminated soil body is shown graphically on Figure 4-18.

No complete analytical sample suites were collected from the contamination body found near UVOST probe UV002. However, multiple correlation samples were collected from the contamination found at the UV002 probe location. It should be noted that the direct comparison of samples collected in accordance with ADEC sampling procedures to samples collected for the correlation sample may not be entirely valid due to the different sample handling procedures. The correlation samples were extensively homogenized and were evaluated by the UVOST tool several times before laboratory analysis. The extensive manipulation of the sample material for the correlation evaluation has likely severely limited the comparability of this data with other normal RI sampling. DRO values within the four correlation samples collected near this probe location ranged from 6.6 to 12,000 mg/kg.

4.2.5.5 AOC C – Power House 001 (C-PR-001)

Five screening boreholes were drilled at this site feature and the locations are identified as 12FMCPR001UV001 through UV005, as shown on Figure C-1 in Appendix L. Figure 4-20 shows the UVOST boring log for UV004. From 0 to 2 feet bgs, the waveform is typical of surface vegetation and roots. From 2 to 7.4 feet bgs, the waveform is typical of clean subsurface soil. From 7.4 to 17.3 feet bgs, the waveform represents a potential fuel signature although the percent fluorescence is relatively small at 1.5%. The waveform changes slightly at 15.8 feet bgs, where the paleosol layer is likely located. From 17.4 to 18.4 feet bgs, the waveform is typical of clean subsurface soil. The highest LIF value is well below the LIF threshold for contamination as determined by the correlation evaluation (1% exsitu and 1.5% insitu).

The waveform from 7.4 to 17.3 feet bgs may represent a potential fuel waveform; however, sampling determined that the contamination is below regulatory levels. A soil sample was collected at this site feature for full suite analysis (12FMCPR001DT003). The sample was collected nearest to UV001 from a depth of 10 to 12 feet bgs. The location and detected contaminants associated with Figure C-1 are shown on Figure C-1 in Appendix M. The results of the POL portion of this sample show that DRO was detected at 3.6 mg/kg, below the PAL of 250 mg/kg, and GRO and RRO were qualified as not detected. See Appendix A for a summary of detected sample results and Section 4.27 for a summary of detections above the PALs.

4.2.5.6 AOC C – Quarters 003 (C-QT-003)

Two screening boreholes were drilled at this site feature and the locations are identified as 12FMCQT003UV001 through UV002. There was a section of rusted pipe found on the ground surface at this site feature, as shown on Figure 4-21. There was also trash within the site feature boundaries, including an empty 5-gallon bucket labeled to have contained recently manufactured 30-wt motor oil (Figure 4-22). Figure 4-23 shows the UVOST boring log for UV001. From a depth of 0 to 0.5 feet bgs, the UVOST log shows a waveform typical of surface vegetation. From 0.6 to 0.8 feet bgs, the log shows a peak of 3.9% fluorescence with a waveform that may be a potential fuel signature. The duration of fluorescence is shorter than typical fuel waveforms and may alternatively represent the tundra root mass. The UVOST log from 0.8 to 12 feet bgs shows a waveform typical of uncontaminated subsurface soil. The log shows a LIF peak in the 12 to 12.7 feet bgs, where there is 1.3% fluorescence in a waveform that may be a potential fuel signature. This level of LIF is below the threshold value determined in the correlation evaluation. From 12.7 to 15.6 feet bgs, the waveform is consistent with clean subsurface soil.

One sample was collected for full suite analysis (12FMCQT003DT001) near screening borehole UV001 at 12 to 14 feet bgs. GRO and DRO were both detected in the soil sample but were below PALs. GRO was detected at 7.8 mg/kg, DRO was detected at 10 mg/kg, and RRO was qualified as not detected. See Figure C-1 in Appendix M for screening and sampling borehole locations and a list of detected contaminants for site feature C-QT-003. See Appendix A for a summary of detected sample results, and Section 4.2.7 for a summary of detections above the PALs.

This feature is a good example of one of the problems associated with targeting very thin contaminant lenses shown as narrow peaks on the UVOST logs. In this case, approximately 30 grams of sample material was collected as a grab sample from the 12 feet bgs zone for analysis of GRO. This GRO sample therefore is indicative of the highest concentration of GRO contamination. Soil was then collected from the 12 to 14 feet bgs zone and homogenized to generate the required volume for the remaining analyses. As the UVOST indicates that the contamination zone was only 0.2 feet in thickness, this may have resulted in a 10X dilution of contaminated soil with clean soil. However, in this case, a contaminant concentration 10X the laboratory result would still be below PALs for DRO and RRO.

4.2.5.7 AOC C – Quarters 023 (C-QT-023)

Two screening boreholes were drilled at this site feature in accordance with the Work Plan. The two screening locations are identified as 12FMCQT023UV001 and UV002. Figure 4-24 shows the UVOST screening borehole log for UV002. By depth, this borehole logs shows waveforms typical of surface vegetation matter from 0 to 0.3 feet bgs, clean soil from 0.3 to 0.7 feet bgs, a possible fuel signature from 0.7 to 1.9 feet bgs with a fluorescence peak of 2.1%, and clean subsurface soil from 2 to 14.3 feet bgs.

One soil sample was collected for full suite analysis (12FMCQT023DT001) near screening borehole location UV002 from 2 to 3 feet bgs. GRO was detected at 7.5 mg/kg (PAL= 300 mg/kg), DRO was detected at 2.9 mg/kg (PAL= 250 mg/kg), and RRO was qualified as not detected. The location of the screening boreholes and sample locations, as well as a listing of detected contaminants, are shown on Figure C-1 in Appendix M. See Appendix A for a summary of detected sample results, and Section 4.2.7 for a summary of detections above the PAL. With an insitu borehole background of 0.8 %RE, the UVOST peak at approximately 1 foot bgs is at or slightly below the threshold level for POL contamination at the PALs.

4.2.5.8 AOC C – Storage 001 (C-ST-001)

Eight screening boreholes were drilled at this site feature and the borehole locations are identified as 12FMCST001UV001 through UV008. UV007 was the only borehole with a possible potential fuel signature. Figure 4-25 shows the UVOST screening borehole log for UV007. From 0 to 1.9 feet bgs, the waveform is consistent with surface vegetation; from 2 to 3.6 feet bgs the waveform peaks at 1.7% fluorescence and is consistent with a potential fuel signature. At 3.7 to 15.1 feet bgs, the waveform is typical of clean subsurface soil. An evaluation of the UVOST log indicates that the average insitu background for the portion of the borehole with the potential fuel signature is approximately 0.6%RE. The potential fuel signature waveform is below the 1.5 %RE threshold for insitu LIF measurements above background and therefore does not represent contamination above the PALs.

One primary soil sample (12FMCST001DT001) was collected from a depth of 2 to 4 feet bgs approximately 30 feet west of this UVOST probe for full suite analysis. The results of the POL portion of this sample show that GRO and DRO were both detected below their respective PALs, with GRO detected at 1.8 mg/kg, DRO detected at 2.3 mg/kg, and RRO being qualified as not detected. The location of the screening boreholes and sample locations, as well as a listing of detected contaminants, are shown on Figure C-1 in Appendix M. See Appendix A for a summary of detected sample results, and Section 4.2.7 for a summary of detections above the PALs.

4.2.5.9 AOC C – Storage Area 011 (C-ST-011)

Five screening boreholes were drilled at this location and are identified as 12FMCST011UV001 through UV005. This feature was found to be grown over with an alder thicket, requiring the field crew to saw alders for access to the drilling locations. The log for screening borehole UV003 shows change in wavelength response within the UVOST log, although there is no increase in % fluorescence compared to the % fluorescence of the vegetative paleosol layer, which may be attributed to the root mass of the alders. Figure 4-26 shows the UVOST screening borehole log for UV003. From 0 to 1 feet bgs, a waveform is consistent with fluorescence of the surface vegetation; from 1.1 to 5 feet bgs shows a waveform signature with an elevated response in the 350-nanometer channel. From 5.1 to 6.5 feet bgs, the log records a waveform that is indicative of clean subsurface soil, from 6.6 to 11.5 feet bgs is the fluorescence of a waveform consistent with the paleosol layer, and from 11.6 to 16.3 feet bgs is a waveform consistent with uncontaminated soil. The change in waveform from 1 to 5 feet bgs may be a very low level fuel signature or conversely may be associated with the alder roots in this zone. However the percent fluorescence is well below the LIF threshold identified by the correlation evaluation (this waveform is approximately 0.5% above the background at maximum) and therefore any possible POL concentrations would be well below the PALs.

One primary soil sample was collected for full suite analysis (12FMCST011DT001) at this site feature from 10 to 12 feet bgs. GRO was detected at 0.88 mg/kg (PAL= 300 mg/kg), DRO was detected at 2.3 mg/kg (PAL= 250 mg/kg), and RRO was qualified as not detected. The location of screening boreholes and sample locations, as well as a listing of detected contaminants, is provided on Figure C-1 in Appendix M. See Appendix A for a summary of detected sample results, and Section 4.2.7 for a summary of detections above the PALs.

4.2.6 Radiological Screening Results

One site feature in AOC C was screened for possible radiological contamination. This site feature was identified as an x-ray laboratory (C-XR-001). This feature was screened with a Ludlum Model 3 gross alpha/beta/gamma meter equipped with a Model 44-9 pancake probe to evaluate the potential for the leakage or disposal of source material associated with the x-ray unit, including the radionuclide cesium-137 and cobalt-60.

A 10-foot grid was laid out within the feature boundary. A borehole was drilled to a depth of 2 feet bgs at each grid point with a stainless steel hand auger. The soil samples were collected every auger bucket full (approximately 6 inches) and were spread in a layer no greater than 0.5 inches thick on a paper plate. The soil was then screened with the Ludlum Model 3.

No radiological readings above background (50 disintegrations per minute) were detected at site feature C-XR-001.

4.2.7 Soil Sampling Results

Thirty-nine full suite primary soil samples, 10 fuels only (POL) primary soil samples, and four PCB primary soil samples were collected from 39 site features in AOC C for analytical laboratory analysis. The type and number of site features where full suite, POL suite, and PCB soil samples were collected are listed in Table 4-5.

Full suite and POL soil samples were generally collected from screening locations that indicated the possible presence of subsurface contamination using UVOST screening. The Triad Team had determined that if there was no contamination indicated by UVOST screening, a sample would be collected at a random location within the site feature from either the top of the mineral soil or near the groundwater interface. The rational was that the top of the mineral soil would be the most likely depth for observing a localized release, whereas the piezometric surface would be an effective location for evaluating a larger release that may be located at some distance. PCB samples were collected from the top 6 inches of soil, composited from a grid measuring 3 meters × 3 meters at possible PCB contaminated areas, or from a 1.5-meter × 1.5-meter grid for known PCB contaminated areas.

Seven site features in AOC C had contaminants detected above project action limits. Chemicals detected include 2-methylnaphthalene, arsenic, bromomethane, total chromium, and DRO.

The following sections provide a discussion, by site feature, of sample results that exceeded the PALs.

4.2.7.1 AOC C – Debris 001 (C-DB-001)

One soil sample was collected for full suite analysis (12FMCDB001DT001 and a duplicate sample 12FMCDB001DT901) was also collected near UVOST screening borehole UV002 from a depth of 4.5 to 5.5 feet bgs. The field crew determined that the very thin lens of contamination in the 3.0 to 3.2 feet depth range was of insufficient quantity to provide the volume required for full suite analysis. Therefore, the larger thickness of contamination near the 5 feet depth was selected for sampling. Total chromium was detected at 370 mg/kg, above the PAL of 25 mg/kg for total chromium in subsurface soil. Due to concerns raised from the high total chromium detection, another soil sample (12FMCDB001DT002) was collected from this location. This second soil sample was collected at the same sample location and submitted for hexavalent chromium analysis (see Figure C-1 in Appendix M for soil sample locations and a list of detected contaminants). Hexavalent chromium was detected at 7.4 mg/kg, below the PAL of 25 mg/kg.

4.2.7.2 AOC C – Latrine 002 (C-LT-002)

One soil sample was collected for full suite analysis (12FMCLT002DT001) near UVOST screening borehole UV001/UV001BF from 4 to 6 feet bgs. Three additional soil samples were collected for POL suite analysis. 12FMCLT002DT002 was also collected the same borehole as DT001 near UVOST screening borehole UV001/UV001BF but at a depth of 14 to 16 feet bgs, 12FMCLT002DT003 was collected near screening borehole UV018 at 14 to 16 feet bgs, and 12FMCLT002DT004 was collected near screening borehole UV008 (see Figure C-1 in Appendix M for screening and sample boreholes locations and a listing of detected contaminants). DRO was detected above the PAL of 250 mg/kg at concentrations ranging from 1,900 to 10,000 mg/kg. 2-Methylnaphtalene was detected at 18 mg/kg (PAL = 6.1 mg/kg). See Appendix A for a complete listing of AOC C soil sample exceedances above project action limits.

4.2.7.3 AOC C – Pump House 001 (C-PH-001)

One soil sample was collected for full suite analysis (12FMCPH001DT001) near UVOST screening borehole UV001 at a depth of 13 to 15 feet bgs. Arsenic was detected at 7.2 mg/kg, above the PAL of 7.05 mg/kg for arsenic in subsurface soil. See Figure C-1 in Appendix M for soil screening and sampling locations and a listing of detected contaminants. Appendix A provides a complete listing of detected soil sample results.

4.2.7.4 AOC C – Power House 001 (C-PR-001)

Two soil samples were collected for PCB analysis (12FMCPR001DT001 and 12FMCPR001DT002), each from a 9-point composite 3-meter grid at 6 inches bgs. One soil sample was collected for full suite analysis (12FMCPR001DT003) near the approximate center of the feature from a depth of 10 to 12 feet bgs (see Figure C-1 in Appendix M for sample locations). Results from both PCB soil samples were below the PAL of 1 mg/kg. Arsenic was detected at 28 mg/kg, above the PAL of 7.05 mg/kg in subsurface soils. See Appendix A for a listing of all soil sample exceedances above the PALs. The locations of the center point of the 9-point composite PCB grid sampling and the associated detected results are shown on Figure C-1 in Appendix M. The PCB grid sampling locations are highlighted in a different color than other grab samples.

4.2.7.5 AOC C – Storage 003 (C-ST-003)

One soil sample was collected for full suite analysis (12FMCST003DT001) near UVOST screening borehole UV006 at a depth of 9 to 12 feet bgs (see Figure C-1 in Appendix M for sample locations and a listing of detected results). Arsenic was detected at 12 mg/kg, above the PAL in subsurface soil (7.05 mg/kg). See Appendix A for a complete listing of soil sample detections.

4.2.7.6 AOC C – Storage 006 (C-ST-006)

One soil sample was collected for full suite analysis (12FMCST006DT001) near UVOST screening borehole UV003 from a depth of 5 to 7 feet bgs (see Figure C-1 in Appendix M for sample locations and a listing of detected results). Arsenic was detected at 8.9 mg/kg, which is above the PAL (7.05 mg/kg). See Appendix A for a complete listing of detected soil sample results.

4.2.7.7 AOC C – Storage 008 (C-ST-008)

One primary soil sample was collected for full suite analysis (12FMCST008DT001) near UVOST screening borehole UV001 from a depth of 4 to 6 feet bgs (see Figure C-1 in Appendix M for sample locations and a listing of detected results). Bromomethane was detected at 0.3 mg/kg (PAL= 0.016 mg/kg). See Appendix A for a complete listing of detected soil sample results.

4.2.8 Groundwater Results

Three groundwater monitoring wells were initially installed to collect sufficient data to determine the direction of groundwater flow. Once the flow direction was determined, a fourth well was installed in the downgradient direction. The four groundwater monitoring wells installed in AOC C include C-MW-001, C-MW-002, C-MW-003, and C-MW-004. The location of the monitoring wells is shown on Figure C-1 of Appendix M.

Three groundwater samples were collected for laboratory analysis from monitoring wells C-MW-001, C-MW-002, and C-MW-003 (sample numbers 12FMCMW001GW001, 12FMCMW002GW001, and 12FMCMW003GW001, respectively). An additional groundwater sample was filtered and submitted for metals analysis from each of the three wells sampled (sample numbers 12FMCMW001GW001F, 12FMCMW002GW001F, and 12FMCMW003GW001F, respectively). In the unfiltered samples, DRO (3,500 micrograms per liter [µg/L], PAL = 1,500 µg/L) and manganese (720 to 750 µg/L, PAL = 320 µg/L) were detected above PALs at monitoring well C-MW-001 located near site feature C-LT-002. The groundwater data were not available before the field crew left the project site. Therefore, EDB analysis was not conducted on groundwater from this well as required by the Work Plan for any well that had POL exceedances. Future sampling from this well should include EDB analysis. See Appendix A for complete listing of groundwater sample detections.

4.2.9 Geophysical Survey Results

An EM-61 digital metal detector was used to conduct geophysical surveys of three site features in AOC C – C-BD-001, C-MM-001, and C-MM-002. Figure P-01 in Appendix P provides an overview of all of the 16 site features surveyed during the 2012 RI. Site feature C-BD-001 was screened on a 60-foot × 217-foot grid, with C-MM-001 and C-MM-002 both being screened on 60-foot × 60-foot grids. The geophysical survey at site feature C-BD-001 was extended north into site feature C-DA-005 to delineate the northern extent of buried metal at C-DB-001. A large amount of surface debris at this location precluded the survey of the most easterly extent of buried debris at C-DB-001.

4.2.9.1 C-BD-001

This site consisted of a dump site with extensive debris (both metal and non-metal) located along the eastern side of the site feature. Within the survey area, no large or concentrated mass of surface metal debris was observed. However, there were numerous pieces of small metal debris scattered throughout the data coverage.

The highest data value (9,650-mV) for this site is located along the eastern side of the survey area approximately 70-feet north of the southern edge of the area (see Figure P-02 in Appendix P). The profiles of the EM data lines indicate that most of the higher data anomalies produce sharp peaks. This area is interpreted to have a concentration of shallow buried metal debris with the greatest concentration occurring in the east central portion of the survey area and indicated by the color contour map of the EM data. The lower, high data value anomalies (i.e., red to orange color contours) are interpreted to be associated with the small pieces of surface metal or relatively smaller, shallow buried metal debris.

4.2.9.2 C-MM-001

The highest data value anomaly (magenta color with peak value of 28-mV) is located in the northwest corner of the grid (60-feet × 60-feet), as shown on Figure P-03 in Appendix P. This anomaly is sharp peaked in profile and is interpreted to be associated with either a small piece of metal that is shallow buried or on the surface. All of the other data anomalies (i.e., magenta color) located in the southeast quadrant of the grid range in peak values from 9-mV to 11-mV. These relatively low value data anomalies are interpreted to be associated with either small, shallow buried pieces of metal or surface metal. However, no pieces of small surface metal were noted at this site.

4.2.9.3 C-MM-002

The highest data value anomaly (magenta color with peak value of 34-mV) is located on the eastern edge of the grid (60-feet × 60-feet), as shown in on Figure P-04 in Appendix P. This anomaly is sharp peaked in profile and is interpreted to be associated with either a small piece of metal that is shallow buried or on the surface. All of the other data anomalies (i.e., magenta color) located in the southern half of the grid range in peak values from 9-mV to 11-mV. These relatively low value data anomalies are interpreted to be associated with either small, shallow buried pieces of metal or surface metal. However, no pieces of small surface metal were noted at this site.

4.2.10 Risk Evaluation for Soils in AOC C

As seen in Table 6-6, the cumulative risk from the COCs is the ILCR of 7×10^{-5}, and the non-cancer HI of 3. The cumulative ILCR is within the CERCLA allowable range of 1×10^{-6} to 1×10^{-4}; however, it is above the ADEC risk acceptance limit of 1×10^{-5}. The HI is above the CERCLA and the ADEC thresholds of HI not exceeding unity.

The majority of the ILCR (6.2×10^{-5}, 86% of the total) results from arsenic. The non-cancer HI is equally contributed by arsenic and chromium. These chemicals are not known to be related to the site activities. As discussed in Section 3.12.2, arsenic and chromium are believed to be naturally occurring, as no sources of these metals were identified in the surface soil samples. With the exclusion of risks from the metals, the net cumulative risk (ILCR 1×10^{-5} and HI of 0.3) would meet the ADEC criteria of ILCR no greater than10^{-5} and HI no greater than 1, and it would also fall within the CERCLA risk acceptance range.

The net cumulative risk (ILCR of 5.2×10^{-6} or 53% of the total) arises from direct contact with soil at a depth of 10 feet bgs from one sample location, C12FMBU001DT001, and inhalation of naphthalene (ILCR of 4.6×10^{-6} or 47% of the total) at a depth of 6 feet bgs from the sample location 12FMLT002DT001. Real exposure at these depths is unlikely. Further, the concentrations of the detected organics 1,2,4-trimethylbenzene, benzo(a)pyrene, dibenz(a,h)anthracene, and naphthalene were below their respective ADEC PALs. The VOC p-isopropyltoluene was also detected in sample; however, it does not have an RBC. If 1,2,4-trimethylbenzene is used as a surrogate for p-isopropyl toluene, the HI of 0.02 is calculated for the 1.1 mg/kg maximum concentration of p-isopropyltoluene. The HI is significantly below the HI threshold of 1.

Based on the above discussion, no further action is necessary for AOC C soils from the risk perspective; however, the petroleum fraction detections GRO and DRO would need to be addressed with respect to the ADEC PALs.

4.2.11 Summary of the RI in AOC C

Eighty-three site features were evaluated in AOC C. A total of 50 site features were investigated by screening with UVOST technology. A total of 327 UVOST screening boreholes were drilled totaling 5,273 feet drilled with the direct push drill rig. Of the 50 site features investigated, UVOST screening detected possible subsurface fuel signatures at nine site features. Of these nine site features, one was a debris site, two were ground scars, one was a latrine, one was a power house, two were quarters/barracks, and two were storage features. Seven of the 9 possible fuel signatures were below the threshold value of 1%RE exsitu or 1.5% insitu that would represent POL contamination above the PALs. The remaining two site features with LIF above the threshold values were C-GS-004 and C-LT-002.

Subsurface contamination was discovered, characterized and delineated at C-LT-002. The total amount of contaminated soil was found to be approximately 832 cubic yards.

One site feature (C-XR-001) was screened for radiological contamination with a Ludlum Model 3 gross alpha/beta/gamma meter. No radiological contamination was detected at the x-ray laboratory site feature, C-XR-001.

Thirty-nine full suite primary soil samples, 10 fuels only (POL) primary soil samples, and 4 PCB primary soil samples were collected from 39 site features in AOC C for analytical laboratory analysis.

Seven site features had contaminants detected above the project action limits. Contaminants detected included 2-methylnaphthalene (18 mg/kg, PAL= 6.1 mg/kg), arsenic (7.2 to 28 mg/kg, PAL= 7.05 mg/kg), bromomethane (0.3 mg/kg, PAL= 0.16 mg/kg), total chromium (370 mg/kg, PAL= 25 mg/kg), and DRO (1,900 to 10,000 mg/kg, PAL= 250 mg/kg).

Four groundwater monitoring wells and one piezometer were installed in AOC C. Three of the four monitoring wells were sampled for full suite analysis and filtered metals. DRO (3,500 µg/L, PAL= 1,500 µg/L) and manganese (720 to 750 µg/L, PAL= 320 µg/L) were detected above PAL at one monitoring well (C-MW-001). See Appendix A for a complete listing of detected soil sample analytical results. Appendix B provides a complete listing of laboratory analytical results. See Figures C-0 and C-1 in Appendix M for the locations of all soil screening and sampling locations, the location of groundwater monitoring well and piezometers, and the geophysical survey areas.

A geophysical survey was conducted at three site features in AOC C and buried metal debris was detected at C-BD-001.

4.2.12 Data Gaps

The following items represent potential data gaps associated with the RI conducted in AOC C:

1. The composition of buried metallic debris at site feature C-BD-001 is unknown.
2. The possible POL contamination observed directly below the suspected sewage discharge pipe at site feature C-GS-004 is undefined.
3. A groundwater sample for EDB analysis should be collected from groundwater monitoring well C-MW-001.
4. The extent of buried piping at site feature C-LT-002 is not defined.

4.3 AOC D

The field investigation in AOC D was conducted from July 25, 2012 through September 17, 2012. During the course of the investigation, four site features were added to the investigation program: 2 antennae site features, 1 transformer site feature, and 1 building unknown site feature. These new site features were included because their field characteristics were similar to site features previously identified (Table 4-1). The newly identified transformer and building unknown site feature were added to the UVOST screening program, making a total of 11 site features investigated by the UVOST. All four newly identified site features were added to the analytical sampling program, making a total of 16 site features where samples for laboratory analysis were collected (Table 4-2). One groundwater monitoring well and two piezometers were installed in AOC D. The history of AOC D, an updated CSM, and a summary of the results of the investigation of AOC D are presented below. Maps with the actual screening and sampling locations and a listing of detected contaminants are provided on Figure D-0 in Appendix M. Photographs of each site feature are provided in the project photographic log in Appendix N.

4.3.1 Historical Use of AOC D Area

Communication operations were conducted within the approximately 1,693-acre AOC D. Figure 4-27 shows the antennae associated with the Civil Aeronautics Administration Range Station as well as the power and transmitter buildings.

4.3.2 Conceptual Site Model

The CSM forms for AOC D have been updated based on screening and sampling results. The CSM graphic form (Figure 4-28) and figures showing potential release mechanisms and potential receptors (Figures 4-29 and 4-30) are provided in the Figures section at the end of the text, and the CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC D included former ASTs, fuel dispensing operations, drums, and transformers. The potential release mechanisms included spills, leaks, and direct discharge. The potentially impacted media in AOC D included surface and subsurface soils, groundwater, air and biota.

Direct contact by incidental soil ingestion is a complete exposure pathway in AOC D. Contaminants were detected above regulatory levels in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants from soil is a complete exposure pathway because contaminants were detected in surface soil that can permeate the skin. Ingestion of groundwater is a complete exposure pathway because contaminants were detected in sampled groundwater and the groundwater in AOC D can potentially be used as a future drinking water source and may be used as a current drinking water source. Ingestion of surface water is an incomplete exposure pathway. Surface water was not present within 50 feet of petroleum contaminated soil; therefore, surface water samples were not collected. Ingestion of wild and farmed foods is a complete exposure pathway. It can be reasonably expected that hunting would take place in AOC D and contamination with the potential to bioaccumulate was present where it could be taken up into biota. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants are present in the soil between 0 and 15 feet bgs. Inhalation of indoor air is a complete exposure pathway because contamination was detected within 30 feet of a potential future building site.

4.3.3 Summary of the Screening and Sampling Activities in AOC D

Table 4-6 provides a summary of the screening and sampling activities conducted in AOC D. The site features with detections by the UVOST system and/or detections in the analytical data above the PAL are discussed in more detail in Sections 4.3.5 and 4.3.6. Maps with the locations of the site features discussed below are provided in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.3.4. The locations of the center point of the 9-point composite PCB grid sampling are shown on Figures D-0 and D-1 in Appendix M. The PCB grid sampling is highlighted in a different color than single point grab samples.

4.3.4 Deviations to the Work Plan in AOC D

During the course of the investigation in AOC D, eight variances from the Work Plan were identified and documented as deviations. A complete listing of the deviations are provided in Table 4-7.

There were eight variances to the work plan in AOC D. Four site features were newly identified during the course of field activities in AOC D. Two of the newly identified site features were screened and sampled. The other two were sampled for PCBs. Two Ground Scar (GS) site features selected for screening and sampling in the work plan were inaccessible to the drill rig due to the topography. Two alternative GS site features were screened and sampled instead.

4.3.5 UVOST POL Screening Results

Eleven site features were screened using UVOST technology in AOC D. A total of 103 UVOST screening boreholes were drilled totaling 1,385 feet drilled; 20 feet in six boreholes was drilled with a stainless steel hand auger, and the remaining 1,365 feet was drilled with a direct push drill rig. Site features screened with the UVOST are listed in Table 4-8.

Of the 11 site features screened in AOC D, UVOST screening identified potential contamination at one site feature – transformer site 002 (D-TF-002), as shown in Table 4-6. Details of the investigation of this site feature are described below. In addition to the discussion of the UVOST screening, the detected analytical laboratory results for GRO, DRO, RRO, PCBs, and metals are discussed.

4.3.5.1 AOC D – Transformer 002 (D-TF-002)

Ten screening boreholes and a butterfly borehole were drilled at this site feature. The screening locations are identified as 12FMDTF002UV001 through 12FMDTF002UV010. Figure 4-31 presents the UVOST screening and soil sampling locations at site feature D-TF-002. Figure 4-32 shows the UVOST screening borehole log for UV002. The log shows clean subsurface soil from 0 to 1.1 feet bgs. The log clearly indicates a fuel signature in the subsurface from 1.2 to 15.1 feet bgs with a peak in fluorescence of 5.8%. The blue-colored waveform indicates the presence of short-chained POL compounds (see Figure 4-32) with the preponderance of LIF in the 350 nanometer channel. A butterfly borehole (UV002BF) was drilled 1 foot to the west of UV002 and found that the contamination was present at a similar depth but with a maximum %RE of 11.9 (see Figure 4-33 for the UVOST log). Figure 4-34 shows the butterfly plot of screening boreholes UV002 and UV002BF. The logs indicate that a subsurface paleosol layer is present from approximately 15 to 20 feet bgs.

Two primary soil samples were collected for full suite analysis from this site feature (12FMDTF002DT007 and 12FMDTF002DT008). Sample 12FMDTF002DT007 was collected from a depth of 6 to 7 feet bgs from a borehole located approximately 2 feet south of UVOST probe UV002. DRO was detected at 2.3 mg/kg (PAL = 250 mg/kg). Sample 12FMDTF002DT008 was collected from a depth of 6 to 7 feet bgs from a borehole located approximately 5 feet north-northwest of UVOST probe UV002. DRO was detected at a concentration within this borehole at 21,000 mg/kg. RRO was detected in these two samples at a range of 12 to 530 mg/kg, respectively (PAL=10,000 mg/kg). The location of these boreholes and the analytical detections are graphically shown on Figure D-0 in Appendix M.

The butterfly UVOST borehole indicates that the contamination levels at this site vary considerably laterally over very short distances as the two probes located only 1 foot apart, show considerably different contamination levels. This variability is also seen in the sample data versus UVOST data for sample 12FMDTF002DT007 and probe UV002, which were separated by only 3 feet. The field team also noted this variability during the collection of soil materials for the correlation evaluation. Samples collected only a few feet to the southeast from UVOST borehole UV002 did not exhibit LIF above background. Soils collected to the northwest did exhibit LIF above background for more than 5 feet laterally but then rapidly declined in %RE LIF.

The volume of soil exceeding the PALs at this site features was computed utilizing the spatial modeling capabilities found within the ArcGIS version 10.1 software. Data input into the model was the LIF measurements for all of the UVOST probe locations at this site feature. Supplemental points representing samples that indicated that the soil was below PALs were also included to more accurately limit the spatial extent. Contouring of the area of contamination was undertaken by interpolating UVOST points to contours of LIF values through the inverse distance weighted spatial modeling. Variable parameters were set as follows:

- Output cell size was left as default (1.546337 10^{-6}),
- Exponent of distance was set to a power of 4, and
- Search radius was set to variable (default) utilizing 20 points.

The volume of the soil was then computed by multiplying the thickness of contamination by the computed square footage of the areal extent of the feature that exceeded 1.5%RE above the insitu background of the borehole. The volume of soil computed through this method is 258 cubic yards. The outline of the contaminated soil body is shown graphically on Figure 4-31. The effective LIF values associated with each of the boreholes at site feature D-TF-002 were computed by subtracting the overall borehole background and disregarding values that were clearly surface vegetation or subsurface paleosol layers.

4.3.6 Soil Sampling Results

Ten full suite primary soil samples, three fuels only (POL) primary soil samples, 87 PCB primary soil samples, and five metal primary soil samples were collected from 16 site features in AOC D for analytical laboratory analysis. The type and number of site features where full suite, POL suite, PCB, and metal suite samples were collected are listed in Table 4-9.

Full suite and POL soil samples were generally collected from screening locations that indicated the possible presence of subsurface contamination using UVOST screening. If there was no contamination indicated with the UVOST, a sample was collected at a random location within the site feature at either near the surface or near the groundwater interface. PCB samples were collected from the top 6 inches of soil, composited from a grid measuring 3 meters × 3 meters for possible PCB contaminated areas, or from a 1.5-meter × 1.5-meter grid for known PCB contaminated areas.

One site feature in AOC D had detections of petroleum contaminants above project action limits. PCBs were not detected at any site features in AOC D. The following section provides a discussion by site feature of the sample results that exceed the PALs.

4.3.6.1 AOC D – Transformer (D-TF-002)

Two primary soil samples were collected for full suite analysis (12FMDTF002DT007 and 12FMDTF002DT008). DRO was detected in sample 12FMDTF002DT008 located 5-feet north of UVOST probe UV002 at a concentration of 21,000 mg/kg (PAL=250 mg/kg). Soil sample 12FMDTF002DT007, located 2 feet south of UVOST probe UV002 identified DRO contamination at a concentration of only 2.3 mg/kg, well below the PAL. This rapid change in soil concentration indicates that the contamination is small in extent and falls below the PAL rapidly in each lateral direction.

Additionally, six primary soil samples were collected at the site feature for 9-point grid PCB analysis (12FMDTF002DT001 through 12FMDTF002DT006). All PCB results were below the PAL. See Figure D-0 in Appendix M for sampling locations and a list of detected results, and Appendix A for a listing of soil sample exceedances above the project action limit.

4.3.7 Groundwater Results

One groundwater monitoring well (D-MW-001) was installed in AOC D at site feature D-TF-002 near field screening location UV002. The well was sampled for full suite analysis (12FMDMW001GW001) and a second sample was collected, filtered, and submitted for metals analysis. The results of both samples indicated there were no COPCs at levels above the project action limit in groundwater in AOC D. The location of monitoring well D-MW-001 is shown on Figure D-0 in Appendix M.

4.3.8 Geophysical Survey Results

An EM-61 digital metal detector was used to a conduct geophysical survey of one site feature in AOC D – Drum Storage 001 (D-DS-001). The highest data value anomaly (magenta color with peak value of 61-mV) is sharp peaked in profile and located in the southwestern quadrant of the survey area (60-feet × 60-feet), as shown in Figure P-05 in Appendix P. The remainder of the higher data value anomalies in this area are sharp peaked in profile and range from 13-mV to 20-mV. It should be noted that this site was hand cleared of building debris prior to the EM61. Numerous pieces of small metal debris were present within the area (i.e., large nails, hinges, small brackets, etc.). It is interpreted that all of the anomalies are associated with small pieces of shallow buried or surface metal.

4.3.9 Risk Evaluation for Soils in AOC D

The ILCR of 1×10^{-6} in soils is within the CERCLA allowable range and the ADEC acceptance limit. There is no non-cancer risk. The PCB Aroclor 1260 (one exceedance out of 106 results) is the only contributor to the risk, and its maximum concentration of 0.36 mg/kg is below the PAL of 1 mg/kg. No further action is necessary for AOC D soil. The petroleum fractions would need to be addressed with respect to the PALs.

4.3.10 Summary of the RI in AOC D

Twenty-four site features were investigated in AOC D and 11 site features were screened with UVOST technology. A total of 103 screening boreholes were drilled with a direct push drill rig totaling 1,385 feet drilled. Of those 11 site features screened with the UVOST, one site feature showed the presence of subsurface contamination; D-TF-002. The total amount of contaminated soil was found to be approximately 258 cubic yards.

Eighty-seven PCB 9-point grid samples were collected from 12 site features at a depth of 6 inches bgs. PCBs were not detected above the PAL (1 mg/kg) at any of the site features in AOC D. Ten primary soil samples were collected for full suite analysis, three samples were collected for POL analysis, and five samples were collected for metals suite analysis. DRO was detected at 21,000 mg/kg (PAL = 250 mg/kg) at D-TF-002. This was the only site feature with contamination above the PALs.

One groundwater monitoring well and two piezometers were installed in AOC D. The monitoring well was sampled for full suite analysis and filtered metals. There were no detections above project action limits in groundwater in AOC D. See Appendix A for a listing of detected groundwater sample results. Appendix O provides a complete listing of groundwater results.

Two piezometers were installed within the AOC in order to determine the AOC specific groundwater flow direction and gradient through the solution of a standard three-point problem. The two piezometers were installed at site features D-UN-001 and D-DS-001.

One site feature in AOC D was screened with an EM-61 digital metal detector and no subsurface anomalies consistent with significant buried metal were found.

4.3.11 Data Gaps

No data gaps were identified during the investigation conducted in this AOC.

4.4 AOC E

The field investigation in AOC E was conducted from August 1, 2012 through October 3, 2012. Ten site features were investigated in AOC E. Of these, seven site features were screened with UVOST technology and analytical soil samples were collected at these seven site features for analytical laboratory analysis (Table 4-2). One of the originally identified site features for screening and sampling (E-DS-001) was found to have buried metal debris during the geophysical survey and as a result was not investigated as the Triad Team had determined that test pits would not be conducted during the first phase of the RI. Additionally, the team determined that UVOST probing would not occur in areas where the probes had the potential to rupture underground tanks or drums. No new groundwater monitoring wells or piezometers were installed in AOC E, although an existing groundwater monitoring well was sampled for full suite analysis.

The history of AOC E, an updated CSM, and the results of the investigation of AOC E are presented below. Maps with the actual screening and sampling locations and a listing of detected results are provided on Figures E-0 and E-1 in Appendix M. Photographs of each site feature are provided in the photographic log in Appendix N.

4.4.1 Historical Use of AOC E Area

Neither the Bush Report (Bush, 1944) nor the Fort Morrow Operations Map (AGC, 2010) indicate that troops were garrisoned within the approximately 2,846 acres that make up AOC E. However, previous investigations and observations from local residents confirm that disposal operations were conducted within this AOC.

4.4.2 Conceptual Site Model

The existing Fort Morrow AOC E CSM has been updated based on screening and sampling results. The CSM graphic form (Figure 4-35) and figures showing potential release mechanisms and potential receptors (Figures 4-36 and 4-37) are provided in the Figures section at the end of the text, and the CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC E included drums, vehicles, and landfill sites. The potential release mechanisms at AOC E include spills, leaks, and direct discharge. The potentially impacted media include surface and subsurface soil, groundwater, air, and biota.

Methylene chloride was detected in four soil samples collected in AOC E. It is likely that this compound is a laboratory contaminant and is not actually present in soils in AOC E. Methylene chloride detects will not be taken into account when discussing complete exposure pathways. Additionally, MTBE was detected in five soil samples and in one re-sample. MTBE was not a World War II era fuel additive and it is likely that the presence of this compound is due to more recent activities. However, it will be taken into account when discussing complete exposure pathways.

Direct contact by incidental soil ingestion is a complete pathway because contaminants were detected in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants from soil is a complete pathway because arsenic, which was detected between 0 and 15 feet bgs, can permeate the skin. Ingestion of groundwater is a complete exposure pathway as metals were detected in groundwater at low levels and groundwater is used as a drinking water source and may continue to be used as a drinking water source in the future. Ingestion of surface water is an incomplete exposure pathway in AOC E. Surface water was not sampled because it was determined that there were no bodies of water that met the approved Work Plan definition of a “significant body of more than 100 square feet located within 50 feet downgradient of contaminated groundwater” (North Wind, 2012).

Ingestion of wild or farmed foods is a complete pathway in AOC E. Arsenic was present above screening levels (7.05 mg/kg), has the potential to bioaccumulate, and was located where it could be taken up into biota. AOC E is an area that could reasonably be used for hunting and harvesting. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected in the soil between 0 and 15 feet bgs. Inhalation of indoor air is a complete exposure pathway in AOC E. There are occupied residences and volatile and petroleum contaminants were detected in groundwater.

4.4.3 Summary of the Screening and Sampling Activities in AOC E

Table 4-10 provides a summary of the screening and sampling activities conducted in AOC E. The site features where UVOST detections and/or detections in the analytical data above the PAL are discussed in more detail in Sections 4.4.5 and 4.4.6. Maps with the locations of the site features discussed below are provided on Figures E-0 and E-1 in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.4.4.

4.4.4 Deviations to the Work Plan in AOC E

During the course of the investigation in AOC E, seven variances from the Work Plan were identified and documented as deviations. A summary of these deviations is provided below and a complete list of the deviations is provided in Table 4-11.

There were seven variances to the work plan in AOC E. Two site features identified for screening and sampling in the work plan were submerged under surface water and were inaccessible to the drill rig. At these site features, soil was collected for screening and sampling with hand augers. The geophysical survey determined the presence of buried metal at three site features. One site feature was not screened or sampled, while soil was collected at the other two site features for screening and sampling using a hand auger. One Ground Scar (GS) site feature selected for screening and sampling in the work plan was submerged and did not have the appearance of being manmade; it was not screened or sampled. An alternate GS site feature was selected for screening and sampling in its place.

4.4.5 UVOST POL Screening Results

Seven site features were screened using UVOST technology in AOC E. A total of 28 UVOST screening boreholes were drilled with a stainless steel hand auger totaling 105 feet drilled. Each of the site features in AOC E was inaccessible to the direct push drill rig; therefore, each screening borehole was drilled with a stainless steel hand auger. Site features screened with the UVOST are listed in Table 4-12. Typically during this investigation, hand auger boreholes were advanced to a depth of 8 feet bgs. However, boreholes within AOC E were limited in depth due to caving below the ground water table. The groundwater in AOC E was encountered at a much shallower depth than most other AOCs.

As shown in Table 4-10, there was no potential POL contamination identified with the UVOST at any of the seven site features screened.

4.4.6 Soil Sampling Results

Seven full suite primary soil samples and three VOC suite primary samples were collected from seven site features in AOC E for analytical laboratory analysis. The type and number of site features where full suite and VOC suite soil samples were collected are listed in Table 4-13.

Three site features have contaminants with detections above the project action limits. COPCs detected include MTBE, methylene chloride, and arsenic. The following sections provide a discussion by site feature of the sample results that exceed the project action limits.

4.4.6.1 AOC E – Dump Site 004 (E-DS-004)

One primary soil sample (12FMEDS004DT001) was collected for full suite analysis near UVOST screening borehole UV002 from 1.5 to 2 feet bgs. Volatiles were identified at this site feature including MTBE which was detected at 2.2 mg/kg (PAL= 1.3 mg/kg) and methylene chloride which was detected at 0.31 mg/kg (PAL= 0.016 mg/kg). A second primary soil sample was collected from the same location 2 months later (12FMEDS004DT002) and analyzed for only VOCs. MTBE was found in low levels in the trip blank of the original sample. The second sample was collected to verify that contamination was not the result of laboratory contaminants, transportation related contamination, or field induced contamination. MTBE and methylene chloride were both qualified as not detected in this second soil sample. See Appendix M for soil sample locations and a listing of detected contaminants. See Appendix A for a listing of detected soil analytical results above PALs.

4.4.6.2 AOC E – Dump Site 005 (E-DS-005)

One primary soil sample (12FMEDS005DT001) was collected for full suite analysis near UVOST screening borehole UV002 from 1 to 2 feet bgs. MTBE was detected at 3.2 mg/kg (PAL= 1.3 mg/kg) and methylene chloride was detected at 0.39 mg/kg (PAL= 0.016 mg/kg). A second primary soil sample was collected from the same location 2 months later (12FMEDS005DT002) and analyzed for only VOCs. MTBE was found in low levels in the trip blank of the original sample. The second sample was collected to verify that contamination was not the result of laboratory contaminants, transportation, related contamination, or field induced contamination. MTBE was detected at 3.9 mg/kg and methylene chloride was qualified as not detected in this second soil sample. See Figure E-0 in Appendix M for soil sample locations and a listing of detected contaminants. See Appendix A for a listing of detected soil analytical results above PALs.

4.4.6.3 AOC E – Other (E-OT-001)

One primary soil sample (12FMEOT001DT001) was collected for full suite analysis near UVOST screening borehole UV001 from 1 to 2 feet bgs. Methylene chloride was detected at 0.41 mg/kg (PAL= 0.016 mg/kg) and arsenic was detected at 7.2 mg/kg, above the PAL for arsenic in subsurface soil (7.05 mg/kg). A second soil sample was collected at the same location 2 months later (12FMEOT001DT002) and was analyzed for only VOCs. MTBE was found in low levels in the trip blank of the original sample. The second sample was collected to verify that contamination was not the result of laboratory contaminants, transportation related contamination, or field induced contamination. MTBE was detected at 3.6 mg/kg (PAL= 1.3 mg/kg). Methylene chloride was qualified as not detected in this second soil sample. See Figure E-0 in Appendix M for soil sample locations and a listing of detected contaminants. See Appendix A for a listing of detected soil analytical results above PALs.

4.4.7 Groundwater Results

No groundwater monitoring wells were installed in AOC E in the 2012 field season. A pre-existing groundwater monitoring well was selected near site feature E-DS-001 for groundwater sampling. Four groundwater monitoring wells exist in AOC E and the least damaged of the wells was selected for sampling. The number assigned to this well could not be determined; therefore, it was assigned the number E-MW-001. A groundwater sample was collected for full suite analysis (12FMEMW001GW001) and a second sample was collected, filtered, and submitted for metals analysis (12FMEMW001GW001F). The results of both groundwater samples indicated contaminants were not present above the PALs.

4.4.8 Geophysical Survey Results

EM-31 and EM-61 digital metal detectors were used to conduct geophysical surveys of three site features in AOC E, including E-DS-001, E-DS-002, and E-DS-003. E-DS-001 was screened on a 140-foot × 200-foot grid using the EM-61 detector and E-DS-002 and E-DS-003 were both surveyed on 60-foot × 60-foot grid using an EM-31 detector.

4.4.8.1 AOC E – Drum Storage 001 (E-DS-001)

This site feature consisted of a large pit where an excavation and drum removal action was previously performed. Limitations to the extent of the data coverage were vegetation (at the northeast and northwest corners) and entrance/exit roads to the local general store (on the northeast and southeast sides of the survey area).

Based on the color contour map of this survey area (Figure P-06 in Appendix P), a concentration of anomalies are observed in the northeast corner. The highest data value within this survey area is an anomaly located approximately 160-feet from the middle from the left side of the survey area. The buried metal at this location produces a sharp peak. Two items of surface metal were noted; 1) a small (2-inch × 8-inch × 1/8-inch) was noted in the very northwest corner of the surface and produced a 190-mV EM61 data value, and 2) a partial exposure of a buried drum located in the northeast portion of the survey area (and northeast corner of the pit area) produced a 2,347-mV data value. The locations of these noted surface metal objects are indicated on Figure P-06 in Appendix P.

All of the anomalies observed within this survey area are interpreted to be associated buried metal debris (with the exception of noted surface metal). The EM profile responses for the data anomalies indicate a mix of sharp and broad peaked responses. This indicates that there is a high potential of both shallow buried and deeper buried metal debris at this site. Based on the EM data for this site, it is clear that the previous excavation and removal action did not remove all of the debris at this location.

4.4.8.2 AOC E – Drum Storage 002 (E-DS-002)

An EM31 metal detector was used to survey site feature E-DS-002 on a 60- × 60-foot grid. Only background values are observed for the grid where EM31 data were acquired. The data from this survey area indicate that the higher value data anomalies within each of the grids are relatively low data values and produce sharp peaks in data profiles. The higher data values within each of these grids are interpreted to be associated with either small pieces of surface or shallow buried metal (Figures P-07 and P-07a in Appendix P).

4.4.8.3 AOC – Drum Storage 003 (E-DS-003)

An EM31 metal detector was used to survey site feature E-DS-003 on a 60 × 60 feet grid. Only background values are observed for the survey area where EM31 data were acquired. The data in this area indicate that the higher value data anomalies within each of the grids are relatively low data values and produce sharp peaks in data profiles. The higher data values within each of these grids are interpreted to be associated with either small pieces of surface or shallow buried metal (Figures P-08 and P-08a in Appendix P).

4.4.9 Risk Evaluation for Soils in AOC E

Arsenic is the sole contributor to the ILCR (2×10^{-5}) and HI (0.3) in soils. The ILCR is within the CERCLA allowable range; however, it is above the ADEC risk acceptance limit. The risk result from the maximum arsenic concentration of 7.2 mg/kg is marginally above the background concentration of 7.05 mg/kg. Arsenic is believed to be naturally occurring. If arsenic is removed from the calculation, then there would be no risk-contributing COPCs remaining for the AOC E soils. The petroleum fractions are not an issue for the AOC E soils and from a risk perspective, no further action is required in this AOC.

4.4.10 Summary of the RI in AOC E

Ten site features were identified for investigation in AOC E. Seven of those features were screened using UVOST technology. A total of 28 screening boreholes were drilled with a total of 105 feet drilled. The drill rig was unable to access any of the site features due to wet tundra and muskeg, therefore soil material was collected from all of the site features through the use of the hand augers. The soil material collected with the hand augers was screened with the UVOST technology in emulation mode. UVOST screening identified no areas of potential contamination in AOC E.

Seven primary soil samples were collected for full suite analysis and three soil samples were collected for VOC suite analysis. MTBE, methylene chloride, and arsenic were detected above project action limits in three site features – E-DS-004, E-DS-005, and E-OT-001. MTBE concentrations ranged from 3.2 to 3.9 mg/kg (PAL= 1.3 mg/kg), the arsenic concentration was 7.2 mg/kg (PAL= 7.05 mg/kg), and methylene chloride concentrations ranged from 0.31 to 0.41 mg/kg (PAL= 0.016 mg/kg).

No groundwater monitoring wells were installed during the 2012 field season. There were several pre-existing groundwater monitoring wells in AOC E, and one was selected near site feature E-DS-001 for groundwater sampling. It was sampled for full suite and filtered metals analysis. There were no detections in groundwater above project action limits in AOC E.

Three site features were screened with EM-31 and EM-61 digital metal detectors to determine the presence of buried metal. One site feature, E-DS-001, was found to have significant anomalies that were interpreted to be associated with buried metal or metallic debris. Therefore, this site feature was not screened or sampled.

4.4.11 Data Gaps

The following item represents a potential data gap associated with the 2012 RI conducted in AOC E:

- The composition and lateral extent of buried metallic debris at E-DS-001 is not clearly defined.

4.5 AOC F

The field investigation in AOC F was conducted from August 2, 2012 through October 19, 2012. During the course of the field investigation, it was determined that three site features had eroded away due to the decreasing marine shoreline in this area, and one site feature was found to be located underneath a USAF temporary PCB soil staging area along the coastline. Sixteen site features were investigated in AOC F (Table 4-1). A total of 11 site features were screened with UVOST technology and soil samples for laboratory analysis were collected from 10 site features (Table 4-2). One monitoring well was installed in AOC F.

The history of AOC F, an updated CSM, and the results of the investigation of AOC F are presented below. Maps with the actual screening and sampling locations and a list of detected results are provided in Appendix M. Photographs of each site feature are provided in Appendix N.

4.5.1 Historical Use of AOC F Area

The advanced party composed of a detachment from Company B of the 807th Engineer landed in AOC F on June 18, 1942. The Task Force #1 composed of the 53rd Infantry Regiment and attached units followed on July 8, 1942. The units initially established a temporary camp site 300 yards northeast of Meshik Village with the first headquarters being located in the Russian Orthodox church. Construction on the permanent barge dock for the unloading of supplies was started in AOC F in mid-August. The units moved into the permanent camp located 3 miles to the northeast later that year. All supplies arriving by barge after the construction of the dock would have moved through and been temporarily stored during unloading in AOC F (Figure 4-38). AOC F is approximately 638 acres in size.

4.5.2 Conceptual Site Model

The existing CSM form has been updated based on the screening and sampling results in AOC F. The CSM graphic form (Figure 4-39) and figures showing potential release mechanisms and potential receptors (Figures 4-40 and 4-41) are provided in the Figures section at the end of the text, and the CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC F included USTs, ASTs, fuel dispensing operations, drums, vehicles, and landfill sites. Potential release mechanisms included spills, leaks, and direct discharges. The potentially impacted media in AOC F included surface and subsurface soils, groundwater, air and biota.

Direct contact by incidental soil ingestion is a complete exposure pathway because contaminants are present in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because the contaminants detected have the ability to permeate the skin. Ingestion of groundwater in AOC F is a complete exposure pathway. Manganese was detected above regulatory limits in the groundwater, and the groundwater could be potentially used as a future drinking water source. It is likely that the manganese is naturally occurring; however, there is no groundwater background data to allow for not including it in this exposure pathway determination.

Ingestion of surface water is an incomplete pathway. Surface water was not sampled because it was determined that there were no bodies of water that met the approved Work Plan definition of a significant body more than 100 square feet located within 50 feet downgradient of contaminated groundwater. Ingestion of wild food is a complete exposure pathway because contaminants were detected that have the potential to bioaccumulate in surface soils and AOC F could be used for hunting and harvesting of wild food. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC F because volatile contaminants were detected in the soil and because it could be reasonably expected that building would occur in the future.

4.5.3 Summary of the Screening and Sampling Activities in AOC F

Table 4-14 provides a summary of the screening and sampling activities conducted in AOC F. The site features where UVOST screening detections and/or detections in the analytical data above the PAL are discussed in more detail in Sections 4.5.5 and 4.5.6. Maps with the locations of the site features discussed below are provided in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.5.4.

4.5.4 Deviations to the Work Plan in AOC F

During the course of the investigation in AOC F, four variances from the Work Plan were identified and documented as deviations. A summary of the deviations is provided below and a complete listing of the deviations is provided in Table 4-15.

There were five variances to the work plan in AOC F. Three site features identified for screening and sampling in the work plan had eroded away due to natural beach erosion and therefore could not be located. One site feature selected for screening and sampling was removed during previous PCB contaminated soil removal activities. This site feature could not be relocated as it no longer exists. One site feature was located within an active PCB soil staging yard and was inaccessible for screening and sampling.

4.5.5 UVOST POL Screening Results

Twelve site features were screened using UVOST technology in AOC F. A total of 78 UVOST boreholes were installed totaling 671 feet drilled; 168 feet in 36 boreholes were drilled with hand augers and the remaining 503 feet were drilled with a direct push drill rig. Site features screened with the UVOST are listed in Table 4-16.

As shown in Table 4-14, of the 12 site features screened in AOC F, potential contamination was identified at two site features. Details of the investigation at both these site features are described below. In addition to the discussion of the UVOST screening results, the detected analytical results of GRO, DRO, and RRO are discussed as well.

4.5.5.1 AOC F – Building Unknown 001 (F-BU-001)

The field team examined this site feature and found that the present building on site is currently used for storage and as a repair shop by one of the local residents. Eight UVOST screening boreholes were drilled at F-BU-001 and are identified as 12FMFBU001UV001 through 12FMFBU001UV008. Figure 4-42 shows the UVOST screening borehole log for UV007. From 0 to 2.2 feet bgs, there is slight fluorescence of surface vegetation and subsurface soil. From 2.3 to 2.7 feet bgs, the waveform is consistent with a potential fuel signature, although the % fluorescence is relatively small at 1.8% maximum. From 2.8 to 4.5 feet bgs, the waveform indicates uncontaminated subsurface soil. From 4.6 to 5.2 feet bgs, the waveform is again consistent with a potential fuel signature and it peaks at 2.6% fluorescence. From 5.3

to 11.2 feet bgs, the waveform is consistent with uncontaminated subsurface soil. Only 25% of the Building Unknown site features in each AOC were selected for screening. Those site features identified for a reduced screening percentage were also sampled at a reduced frequency of 10% for the full suite of COPCs. Site feature F-BU-001 was selected for screening but not sampling; therefore, no samples were collected. The correlation study indicates that this contamination may exceed the PALs.

It may be advantageous to collect a subsurface soil sample from directly adjacent to UV007 at a depth of 4.6 to 5.2 feet to conclusively determine if this site exceeds the PALs.

4.5.5.2 AOC F – Other 001 (F-OT-001)

The field team evaluated the site feature and found that most of the feature was taken up by a septic tank drain field for the non-Fort Morrow building located directly to the north. Nine screening boreholes were drilled at F-OT-001 with the locations identified as 12FMFOT001UV001 through 12FMFOT001UV009. Figure 4-43 shows the UVOST screening borehole log for UV004. From 0 to 0.3 feet bgs, the log shows the fluorescence typical of surface vegetation. From 0.4 to 3 feet bgs, the waveform is indicative of clean subsurface soil. However, from 3.1 to 5.7 feet bgs, the waveform is consistent with a fuel type waveform and has a peak in % fluorescence at 2.5%RE. Below the area of contamination is a waveform indicative of clean subsurface soil from 5.8 to 9.4 feet bgs, followed by a waveform indicating the subsurface paleosol layer from 9.5 to 10.6 feet bgs.

Two full suite soil samples were collected from F-OT-001 (12FMFOT001DT001 and 12FMFOT001DT002). DT002 was collected from near screening location UV004 from 4 to 5 feet bgs. GRO was qualified as not detected and DRO was detected at 5,400 mg/kg (PAL= 250mg/kg).

The volume of soil exceeding the PALs at this site features was computed utilizing the spatial modeling capabilities found within the ArcGIS version 10.1 software. Data input into the model was the LIF measurements for all of the UVOST probe locations. Supplemental points representing samples that indicated that the soil was below PALs were also included to more accurately limit the spatial extent. Contouring of the area of contamination was undertaken by interpolating UVOST points to contours of LIF values through the inverse distance weighted spatial modeling. Variable parameters were set as follows:

- Output cell size was left as default ($1.546337\ 10^{-6}$),
- Exponent of distance was set to a power of 4, and
- Search radius was set to variable (default) utilizing 20 points.

The volume of the soil was then computed by multiplying the thickness of contamination by the computed square footage of the areal extent of the feature that exceeded 1.5%RE above the insitu background of the borehole. The volume of soil computed through this method is 43 cubic yards. The outline of the contaminated soil body is shown graphically on Figure 4-44.

The volume computations were based upon the effective LIF maximums found in each of the boreholes at the site feature. The effective LIF values associated with each of the boreholes in site feature F-OT-001 were computed by subtracting the overall borehole background and disregarding values that were clearly surface vegetation or subsurface paleosol layers.

The area to the southeast of the drain field was not accessible to the drill rig and no UVOST probes were advanced in that direction. Two additional hand auger holes and UVOST evaluation of that collected soil may be required in order to definitively determine the lateral extent of the contamination. An additional soil sample may be required if the UVOST data indicated higher contaminant levels to the southeast.

4.5.6 Soil Sampling Results

Ten full suite primary soil samples and one POL suite primary soil sample were collected from nine site features in AOC F for laboratory analysis. The type and number of site features where full suite and POL samples were collected are listed in Table 4-17.

Two site features had detections above the project action limits (F-OT-001 and F-OT-003). Chemicals detected include MTBE and DRO.

4.5.6.1 AOC F – Other 001 (F-OT-001)

Two primary soil samples were collected for full suite analysis. One soil sample (12FMFOT001DT001) was collected near screening borehole UV002 from a depth of 4 to 5 feet bgs. MTBE was detected in this sample at 1.6 mg/kg (PAL= 1.3 mg/kg). A second soil sample (12FMFOT001DT002) was collected near screening borehole UV004 from a depth of 4 to 5 feet bgs. See Figure F-0 in Appendix M for soil sampling locations and a list of detected contaminants. DRO was detected in this sample at 5,400 mg/kg (PAL= 250 mg/kg). See Appendix A for a complete listing of detected soil sample results above the PAL.

4.5.6.2 AOC F – Other 003 (F-OT-003)

UVOST screening at site feature F-OT-003 did not indicate any areas of likely POL contamination. The logs do indicate several zones of organic rich soil or paleosols. The field team was able to verify this observation by examining the ocean beach cut bank located only 40 feet to the west. One soil sample was collected for full suite analysis (12FMFOT003DT001) near screening borehole UV002 from a depth of 3 to 4 feet bgs. The depth of collection for this sample was selected as the top of the piezometric surface in accordance with the Triad Team decisions. MTBE was detected at a concentration of 1.6 mg/kg (PAL= 1.3 mg/kg) within this soil sample. See Appendix A and Figure F-0 in Appendix M for a listing of detected soil results above the PAL.

4.5.7 Groundwater Results

One groundwater monitoring well, F-MW-001, was installed in AOC F west of site feature F-OT-001, and there was one exceedance of the PALs.

4.5.7.1 Groundwater Monitoring Well F-MW-001

One groundwater sample was collected for full suite analysis (12FMFMW001GW001) and a second sample was collected, filtered, and submitted for metals only analysis (12FMFMW001GW001F). Manganese was detected at 350 µg/L in both groundwater samples at levels above the PAL (PAL= 320 µg/L). See Figure F-0 in Appendix M for the groundwater monitoring well location. See Appendix A for a listing of detected groundwater results above the PAL.

4.5.8 Geophysical Survey Results

EM-61 and EM-31 digital metal detectors were used to conduct a geophysical survey of two site features in AOC F – F-BD-001 and F-DS-001. Site feature F-BD-001 was screened with an EM-31 instrument on a 60-foot × 60-foot grid and site feature F-DS-001 was screened with an EM-61 instrument on a 60-foot × 90-foot grid.

4.5.8.1 AOC F – Buried Drum 001 (F-BD-001)

The data for this survey area was acquired using an EM31 instrument. The EM31 instrument was chosen due to the surface conditions at this site. The site consisted of waste high grass with a thick vegetative mat (i.e., dead grass) and standing water in the low areas within the area. The EM31 is a shoulder carried instrument as compared to the more difficult options (i.e., skirt or stretcher bearing methods) for carrying an EM61 instrument without the use of a wheeled cart. EM color contour maps are produced for two components of the EM31 data set; 1) apparent ground conductivity and, 2) in-phase. The in-phase component provides the best sensitivity to buried metal. The map of the apparent ground conductivity is shown on Figure P-09 and P-09a in Appendix P.

Based on the color contour of the EM31 in-phase component, two (2) anomalies are observed in the northwest corner and along the southern edge of the survey area. The relatively large anomaly in the northwest corner is associated with a boat trailer (i.e., surface metal). The other anomaly (on the southern edge of the area) is either associated with surface metal or shallow buried metal. It should be noted that drums or partial drums were observed near and around this grid site. Due to the thick vegetative mat, it could not be determined if this anomaly was associated with either a surface drum or other types of surface metal, or with a shallow buried drum or other type of metal debris. All of the other higher data values (relatively lower, high data value anomalies in magenta color) in this area are interpreted to be associated with smaller pieces of metal debris at or near the ground surface.

4.5.8.2 AOC F – Drum Storage 001 (F-DS-001)

The grid layout for this site was designed such that the western side of the grid was located on the ledge above a cut bank (approximately 3-foot to 5-foot bank) along the beach. The western extent of the grid was limited by the cut bank ledge. However, the grid coverage was also limited by thick brush and alder vegetation along the eastern edge of the grid. While walking along the beach, concentrated metal debris was observed in the cut bank buried below the ground surface on the uphill side of the ledge.

The concentrated EM data anomalies in this survey area were associated with this metal debris as shown in the color contour map of the EM data (see Figure P-10 in Appendix P). The highest data value (5,316-mV) for this site occurs approximately in the center along the very western edge of the data coverage. This location coincides with the highest concentration of metal debris observed along the cut bank. The higher data value anomaly in the southeast quadrant and along the eastern edge of the grid has a data value of 2,086-mV. This is interpreted to be associated with shallow buried metal debris (i.e., a drum or other relatively larger mass of metal debris). Thus, this site has the largest concentration of buried debris observed from the geophysical survey at Port Heiden, AK.

The eastern anomalies are separated from the anomalies associated with the beach debris by a narrow area with no debris. The eastern section is therefore a separate area of debris not associated with the feature currently eroding into the sea. UVOST probing was conducted within the small area between the two debris areas to examine the possible presence of POL contamination associated with either of these dumps, and no contamination was found.

4.5.9 Risk Evaluation for Soils in AOC F

There are no risk-contributing COPCs in the AOC F soil. In addition to the petroleum fraction DRO, p-isopropyltoluene was detected at the maximum concentration of 0.16 mg/kg. The DRO and p-isopropyltoluene coexist. The DRO is below the PAL, and there is no RBC for p-isopropyltoluene. Using 1,2,4-trimethylbenzene as a surrogate for p-isopropyltoluene, the HI of 0.003 is calculated, which is significantly below the HI threshold of 1. Based on these facts, no further action is required for the AOC F soil.

4.5.10 Summary of the RI in AOC F

Sixteen site features were investigated in AOC F. Twelve of the site features were screened with UVOST technology. A total of 78 boreholes were drilled totaling 671 feet. Of those 12 site features screening with the UVOST, two showed the presence of possible subsurface POL contamination.

Ten full suite primary soil samples and one POL suite soil sample were collected from nine site features in AOC F. Two site features were found to have detected contamination above project action limits – F-OT-001 and F-OT-003. These detected contaminants include DRO (5,400 mg/kg, PAL= 250 mg/kg) and MTBE (1.6 mg/kg, PAL= 1.3 mg/kg).

One groundwater monitoring well was installed in AOC F and was sampled for the full suite of analytes and a filtered sample was also collected for metals analysis. There was a single detection of manganese above the project action limit in both the unfiltered and filtered metal samples.

Two site features were surveyed with a high resolution metal detector to determine the presence of buried metal. One site feature, F-DS-001, was found to have anomalies associated with buried metal.

4.5.11 Data Gaps

The following items represent potential data gaps associated with the 2012 RI conducted in AOC F:

1. The amount and composition of buried metallic debris at site feature F-DS-001 is unknown.
2. The possible POL contamination observed at site feature F-BU-001 has not been sampled.
3. The contamination found at site feature F-OT-001 may not be adequately bounded to the southeast.

4.6 AOC G

The field investigation in AOC G was conducted from July 22, 2012 through August 18, 2012. One site feature was investigated in AOC G. This site feature was screened with the UVOST and one soil sample collected for full suite analysis (Table 4-2). No monitoring wells or piezometers were installed in AOC G. The site feature in AOC G was inaccessible to the drill rig; therefore, the four boreholes were drilled with a stainless steel hand auger and screened on the UVOST in emulation mode.

4.6.1 Historical Use of the AOC G Area

Neither the Bush Report (Bush, 1944) nor the Fort Morrow Operations Map (AGC, 2010) indicate that troops were garrisoned within the approximately 244 acres that make up AOC G. However, the Triad Team identified one area of potential concern that was investigated under the first phase of this RI. The one site feature in AOC G is listed as an “Other” feature and was identified in the AGC report as an area “of possible buildings or vegetation.” During the feature identification portion of the investigation, it was noted that G-OT-001 has no obvious anthropogenic features and is quite difficult to access in general. The AOC is marshy with surface water a foot deep in many places and was not likely an area of extensive human activity or disturbance.

4.6.2 Conceptual Site Model

An updated CSM (Figure 4-45) and figures showing potential release mechanisms and potential receptors (Figures 4-46 and 4-47) are provided in the Figures section at the end of the text. The results of the investigation are presented below. Maps with actual screening and sampling locations are provided on Figure G-0 in Appendix M. Photographs of the site feature are provided in Appendix N.

Potential sources of contamination in AOC G included drums. Potential release mechanisms included spills, leaks, and direct discharges. The potentially impacted media in AOC G included surface and subsurface soils, groundwater, air and biota.

Direct contact by incidental soil ingestion is a complete exposure pathway because metal contaminants were detected in the soil between 0 and 15 feet bgs. It is likely that the methylene chloride that was detected is a laboratory contaminant and is not an environmental contaminant in AOC G. Dermal absorption of contaminants is a complete exposure pathway because arsenic, which is capable of permeating the skin, was detected in the soil. Ingestion of groundwater in AOC G is an incomplete exposure pathway; groundwater in AOC G was not sampled. The "site feature" was not obvious – there was standing surface water and the AOC is remote and away from human inhabitants that one would not reasonably expect the groundwater to be used as a future source of drinking water. Surface water was not sampled in this AOC.

Ingestion of wild food is a complete exposure pathway because metal contaminants were detected that have to potential to bioaccumulate and AOC G could be used for hunting and harvesting of wild food. Inhalation of outdoor air is an incomplete exposure pathway because the only volatile contaminant detected was methylene chloride and it is considered a laboratory contaminant. Inhalation of indoor air, or vapor intrusion, is an incomplete pathway in AOC G because no volatile contaminants were detected in the soil and it is not likely residences would be constructed in this AOC due to the presence of standing water.

4.6.3 Summary of the Screening and Sampling Activities in AOC G

Table 4-18 provides a summary of the screening and sampling activities conducted in site feature G-OT-001 in AOC G. Soil from this site feature did not have detections on the UVOST system. There was one chemical detection above project action limits for methylene chloride in the soil. A map with the location of the site feature is provided on Figure G-0 in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.6.4.

4.6.4 Deviations to the Work Plan in AOC G

During the course of the investigation in AOC G, one variance from the Work Plan was identified and documented as a deviation. A summary of this deviation is provided below and a listing is provided in Table 4-19.

There was one variance to the work plan in AOC G. The only site feature identified in AOC G was determined to be in a remote area with over a foot of standing water. This site feature was inaccessible to the drill rig. Soil was collected for screening and sampling using a hand auger instead of a drill rig.

4.6.5 UVOST POL Screening Results

One site feature was screened using UVOST technology (in emulation mode) in AOC G; G-OT-001. A total of four boreholes were drilled using stainless steel hand augers totaling 14 feet.

As shown in Table 4-18, UVOST screening in AOC G did not detect any potential contamination.

4.6.6 Soil Sampling Results

One full suite primary soil sample was collected in AOC G at site feature G-OT-001. The sample was collected from UVOST screening borehole UV003 at a depth of 2 feet bgs. This sample depth was the depth of the first mineral soil below the vegetative root mass. Methylene chloride was detected at 0.022 mg/kg (PAL= 0.016 mg/kg).

This soil sample had only two detections of organics, methylene chloride (22 mg/kg) and bis (2-ethylhexyl)phthalate (0.11 mg/kg), both of which are common laboratory contaminants. The detections were below the LOQ, and in the concentrations ranges generally experienced with the laboratory blanks. The method blank associated with the sample did not contain these chemicals, which is a common occurrence. Also, the sample was collected from the top 2 feet of the soil. It is highly unlikely that methylene chloride is present in the surface soil after decades of inactivity at the site. More than likely, methylene chloride and bis(2-ethylhexyl)phthalate are both laboratory contaminants.

4.6.7 Groundwater Results

There were no groundwater monitoring wells installed in AOC G and no groundwater samples collected.

4.6.8 Geophysical Survey Results

A geophysical survey was not conducted in AOC G.

4.6.9 Risk Evaluation for Soils in AOC G

There are no risk-contributing or petroleum hydrocarbon COPCs in AOC G soil. No further action is necessary for the AOC G soil.

4.6.10 Summary of the RI in AOC G

One site feature was screened and sampled in AOC G, G-OT-001. A total of four boreholes were drilled with a stainless steel hand auger, totaling 14 feet. No screening boreholes showed the presence of potential subsurface contamination.

One soil sample was collected for full suite analysis and showed methylene chloride contamination present at a concentration above the project action limit (0.022 mg/kg, PAL= 0.016 mg/kg).

No groundwater monitoring wells were installed and no groundwater samples were collected in AOC G.

No geophysical surveys were conducted in AOC G.

4.6.11 Data Gaps

No data gaps were identified during the investigation conducted in this AOC.

4.7 AOC H

The field investigation in AOC H was conducted from August 8, 2012 through October 3, 2012. Thirty-one site features were identified for investigation in AOC H (Table 4-1). Twenty-five site features were screened with the UVOST and soil samples were collected at each of the 25 site features screened (Table 4-2). One groundwater monitoring well was installed and sampled in AOC H.

The history of AOC H, an updated CSM form, and the results of the investigation in AOC H are presented below.

4.7.1 Historical Use of the AOC H Area

The Bush Report (Bush, 1944) indicates that AOC H was used for the storage of fuels. The Bush Report also shows a proposed pipeline from the dock in AOC F to this area. The pipeline was not built due to the termination of construction in the fall of 1943. Fuel was stored in drums placed into excavated fuel storage depressions. It is not known what kinds of fuel were stored in the depressions. AOC H is approximately 429 acres in size.

4.7.2 Conceptual Site Model

The CSM forms for AOC H have been updated based on screening and sampling results. The CSM graphic form (Figure 4-48) and figures showing potential release mechanisms and potential receptors (Figures 4-49 and 4-50) are provided in the Figures section at the end of the text. The CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC H included ASTs, fuel dispensing activities, vehicles, and drums. Potential release mechanisms included spills, leaks, and direct discharges. The potentially impacted media in AOC H included surface and subsurface soils, groundwater, air and biota.

MTBE was detected in two soil samples and one soil re-sample. MTBE is not a World War II fuel additive and it is likely that the presence of this compound in the environment is related to more recent activities. Direct contact by incidental soil ingestion is a complete exposure pathway because contaminants were detected in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because contaminants with the potential of permeating the skin were detected in the soil. Ingestion of groundwater in AOC H is a complete exposure pathway because metal contaminants were detected in low levels in groundwater. Surface water was not sampled in this AOC.

Ingestion of wild food is a complete exposure pathway because arsenic, which as the potential to bioaccumulate was detected and AOC H could be used for hunting and harvesting of wild food. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC H because volatile and petroleum contaminants were detected in the soil in an area within 30 feet of a potential future building location.

4.7.3 Summary of the Screening and Sampling Activities in AOC H

Table 4-20 provides a summary of the screening and sampling activities conducted in AOC H. The site features with detections by the UVOST system and/or detections in the analytical data above the PAL are discussed in more detail in Sections 4.7.5 and 4.7.6. Maps with the locations of the site features discussed below are provided on Figure H-0 in Appendix M. There were no deviations to the technical approach to the Work Plan in AOC H.

4.7.4 Deviations to the Work Plan

There were no variances to the work plan in AOC H.

4.7.5 UVOST POL Screening Results

Twenty-five site features were screened (Table 4-21) using UVOST technology in AOC H. A total of 111 screening boreholes were drilled, totaling 1,434 feet; 362 feet in 57 boreholes were drilled with a hand auger and the remaining 1,072 feet were drilled with a direct push drill rig.

As shown in Table 4-20, no potential contamination was detected in AOC H by the UVOST system.

4.7.6 Soil Sampling Results

Twenty-five full suite primary soil samples and three VOC suite soil samples were collected from 25 site features in AOC H. Two of the site features had detections of MTBE in the soil samples collected. MTBE has been used in gasoline within the United States at low levels since 1979 to replace tetraethyl lead and also to increase the fuels octane rating. The use of MTBE before that time was not common. As it appeared that this compound may be a result of a more recent fuel, samples from those site features were re-collected for VOC analysis to determine if the contamination was due to possible field contamination of the sampling equipment, laboratory contamination, or if the this chemical was indeed present at the site feature. The type and number of the site features where full suite soil samples and VOC suite soil samples were collected are listed in Table 4-22. The following sections provide a discussion by site feature of the sample results that exceed the project action limits.

4.7.6.1 AOC H – Building Unknown 007 (H-BU-007)

One primary soil sample (12FMHBU007DT001) was collected for full suite analysis near screening borehole UV004 from a depth of 2 to 3 feet bgs. MTBE was detected at 7.7 mg/kg (PAL = 1.3 mg/kg). A second soil sample (12FMHBU007DT002) was collected for reanalysis of VOCs and MTBE was detected at 3.5 mg/kg in the resample soil. The sample location and a list of detected contaminants are provided on Figure H-0 in Appendix M.

4.7.6.2 AOC H – Fuel Storage 020 (H-FS-020)

One primary soil sample was collected (12FMHFS020DT001) for full suite analysis near screening borehole UV004 from a depth of 2 to 3 feet bgs. MTBE was detected at 1.8 mg/kg (PAL = 1.3 mg/kg). The sample location and a list of detected contaminants is provided on Figure H-0 in Appendix M.

4.7.7 Groundwater Results

One groundwater monitoring well (H-MW-001) was installed and sampled in AOC H. One groundwater sample was collected for full suite analysis (12FMHMW001GW001) and one sample was collected, filtered, and submitted for metals analysis (12FMHGW001MW001F). The results of the two samples indicate contamination is not present above PALs in the groundwater. Figure H-0 in Appendix M shows the location of well H-MW-001 and provides a listing of all detected contaminants.

4.7.8 Geophysical Survey Results

A geophysical survey was not conducted in AOC H.

4.7.9 Risk Evaluation for Soils in AOC H

There are no risk-contributing or petroleum hydrocarbon COPCs in AOC H soil. No further action is necessary for the AOC H soil.

4.7.10 Summary of the RI in AOC H

Twenty-five site features were screened with UVOST technology. A total of 111 screening boreholes were drilled, totaling 1,434 feet. No potential subsurface contamination was detected with the UVOST at any of the 25 site features screened.

Twenty-five primary soil samples were collected for full suite analysis and three soil samples were collected for VOC suite analysis. Samples collected at two site features had MTBE detections above the project action limit. The range of MTBE concentrations was 1.8 to 7.7 mg/kg (PAL= 1.3 mg/kg). MTBE was not used in fuel during the occupation of the site by the U.S Army during 1942 and 1943. MTBE has a relatively higher water solubility and persistence than other components of gasoline, which can cause it to travel faster and farther than many of the other gasoline components. The presence of MTBE may be indicative of a more recent non-Fort Morrow release of gasoline.

One groundwater monitoring well was installed in AOC H and was sampled for the full analytical suite. A second filtered groundwater sample was collected for metal analysis only. There were no contaminant detections in groundwater above project action limits in AOC H.

A geophysical survey was not conducted in AOC H.

4.7.11 Data Gaps

No data gaps were identified during the investigation conducted in this AOC.

4.8 AOC I

The field investigation in AOC I was conducted from August 4, 2012 through August 24, 2012. Five site features were investigated in AOC I. Three site features were screened with UVOST technology and analytical soil samples were collected from the same three site features (Table 4-2). Two groundwater monitoring wells were installed and sampled in AOC I.

The history of AOC I, an updated CSM, and the results of the investigation of AOC I are presented below.

4.8.1 Historical Use of the AOC I Area

The Bush Report (Bush, 1944) indicates that the very northern portion of AOC I may have been used by the Quartermaster Detachment. Much of the approximately 389 acres of AOC I was used for quartering personnel in tents. The AGC operations map indicates that the most extensive use of the AOC was for defensive positions. The field crew identified many areas with double notched 24-inch tent stakes and remnants of tent canvases. Areas of residual coal storage piles were also found.

4.8.2 Conceptual Site Model

The CSM forms for AOC I have been updated based on screening and sampling results. The CSM graphic form (Figure 4-51) and figures showing potential release mechanisms and potential receptors (Figures 4-52 and 4-53) are provided in the Figures section at the end of the text. The CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC I included fuel dispensing activities, vehicles, and drums. Potential release mechanisms included spills, leaks, and direct discharges. The potentially impacted media in AOC G included surface and subsurface soils, groundwater, air, and biota.

Methylene chloride was the only chemical detected in soil samples above the PAL. Methylene chloride is a common laboratory contaminant and it is unlikely that it is a true environmental contaminant in AOC I. It will not be considered when making exposure pathway determinations.

Direct contact by incidental soil ingestion is a complete exposure pathway because metal and volatile contaminants were detected in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because contaminants with the potential of permeating the skin were detected in the soil, such as arsenic. Ingestion of groundwater in AOC I is a complete exposure pathway because metal contaminants were detected in groundwater at low levels. Surface water was not sampled in this AOC.

Ingestion of wild food is a complete exposure pathway because metal contaminants were detected that have to potential to bioaccumulate and AOC I could be used for hunting and harvesting of wild food. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected in soil between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC I because volatile and petroleum contaminants were detected in the soil in an area within 30 feet of a potential future building location.

4.8.3 Summary of the Screening and Sampling Activities in AOC I

Table 4-23 provides a summary of the screening and sampling activities conducted in AOC I. The site features with detections by the UVOST system and/or detections in the analytical data above the PAL are discussed in more detail in Sections 4.8.5 and 4.8.6. Maps with the locations of the site features discussed and a listing of detected contaminants are provided on Figures I-0 and I-1 in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.8.4.

4.8.4 Deviations to the Work Plan

There were no variances to the work plan in AOC I.

4.8.5 UVOST POL Screening Results

Three site features were screened using UVOST technology in AOC I. A total of 52 screening boreholes were drilled, totaling 948 feet; 32 feet in five boreholes were drilled with stainless steel hand augers and the remaining 916 feet were drilled with the direct push drill rig. Site features screened with the UVOST are listed in Table 4-24.

As shown in Table 4-23, UVOST screening identified potential contamination at one site feature. Details of the investigation of this site feature are described below. In addition to the discussion of the UVOST screening, the detected results of GRO, DRO, and RRO are also discussed.

4.8.5.1 AOC I – Quarters 001 (I-QT-001)

Thirty-four screening boreholes were drilled at this site feature with the direct push drill rig. The UVOST boreholes were identified as 12FMIQT001UV001 through 12FMIQT001UV034. Figure 4-54 shows the UVOST screening borehole log for UV019. From 0 to 16.2 feet bgs, the waveform is consistent with clean subsurface soil. At 16.3 feet bgs, the waveform becomes typical of subsurface paleosol fluorescence which has a characteristically extremely short duration fluorescence with the highest peak being in the 450 nanometer channel. The suspected contamination is found in the middle of the paleosol layer from approximately 18.1 to 18.4 feet bgs. This area is evident by the much longer duration fluorescence shown by the long “tails” on each channels peak. The largest response is seen in the 400 nanometer channel. The response in the 350 nanometer channel is very low, indicating that this contamination is composed of heavier PAH molecules. Below 18.5 feet, the waveform again looks like the typical paleosol fluorescence.

One soil sample was collected for full suite analysis (12FMIQT001DT001) near UV019 at a depth of 18 to 20 feet bgs. The soil sample total length of interval was somewhat longer than the UVOST indicated zone of contamination in order to provide sufficient soil material for the full suite sample. GRO was detected at 3.1 mg/kg (PAL= 300 mg/kg), DRO was detected at 33 mg/kg (PAL= 250 mg/kg), and RRO was detected at 620 mg/kg (PAL= 10,000 mg/kg). The proportional ratios of these constituents are consistent with the UVOST log. See Figure I-1 in Appendix M for screening and sampling locations and a listing of detected contaminants.

4.8.6 Soil Sampling Results

Three full suite primary soil samples and four POL suite primary soil samples were collected from three site features in AOC I for analytical laboratory analysis – I-QT-001, I-GS-002, and I-GS-003. The type and number of site features where full suite and POL suite soil samples were collected are listed in Table 4-25. One site feature, I-QT-001, had a detection of methylene chloride above the PAL.

4.8.6.1 AOC I – Quarters 001 (I-QT-001)

One soil sample was collected for full suite analysis (12FMIQT001DT001) near UVOST screening borehole UV019 from a depth of 18 to 20 feet bgs. Methylene chloride was detected at 0.13 mg/kg (PAL= 0.016 mg/kg). Appendix A provides a listing of detected contaminants in soil.

The detection of methylene chloride was below the LOQ, and in the concentrations ranges generally experienced with the laboratory blanks. The method blank associated with the sample did not contain this chemical, which is a common occurrence. It is highly unlikely that methylene chloride is present in the surface soil after decades of inactivity at the site.

4.8.7 Groundwater Results

Two groundwater monitoring wells (I-MW-001 and I-MW-002) were installed and sampled in AOC I. Two primary groundwater samples were collected for full suite analysis (12FMIMW001GW001 and 12FMIMW002GW001), and an additional sample was collected from each well, filtered, and submitted for metals only analysis (12FMIMW001GW001F and 12FMIMW002GW001F). There were no detections in groundwater above project action limits in AOC I.

4.8.8 Geophysical Survey Results

No geophysical surveys were conducted in AOC I.

4.8.9 Risk Evaluation for Soils in AOC I

There are no risk-contributing or petroleum hydrocarbon COPCs in AOC I soil. No further action is necessary for the AOC I soil.

4.8.10 Summary of the RI in AOC I

Five site features were investigated in AOC I. Three site features were screened with UVOST technology. A total of 52 screening boreholes were drilled, totaling 948 feet. Of those three site features screened with the UVOST, one showed the presence of possible subsurface contamination.

Three soil samples were collected for full suite analysis and four soil samples were collected for POL analysis from three site features. One site feature, I-QT-001, had methylene chloride detected above the project action limit at a concentration of 0.13 mg/kg (PAL= 0.016 mg/kg).

Two groundwater monitoring wells were installed in AOC I. Both groundwater monitoring wells were sampled for full suite analysis and filtered metals. There were no detections in groundwater above project action limits in AOC I.

A geophysical survey was not conducted in AOC I.

4.8.11 Data Gaps

No data gaps were identified during the investigation conducted in this AOC.

4.9 AOC J

The field investigation in AOC J occurred from September 11, 2012 through October 14, 2012. Sixty-eight site features were identified for investigation in AOC J (see Table 4-1). Thirty-two site features were screened with UVOST technology in AOC J. Twenty-eight soil samples were collected for full suite analysis, 16 soil samples were collected for POL suite analysis, 9 soil samples were collected for PCB analysis, and 1 soil sample was collected for metals analysis from 26 site features (Table 4-2). Four groundwater monitoring wells and three piezometers were installed in AOC J.

The history of AOC J, an updated CSM, and the results of the investigation of AOC J are presented below.

4.9.1 Historical Use of AOC J Area

The Bush Report (Bush, 1944) and the Fort Morrow Operations Map (AGC, 2010) indicate that AOC J was used by the Quartermaster Detachment and Quartermaster Casual Company for supply operations. The approximately 352-acre area contained multiple Quonset Huts in the western portion that provided housing for the soldiers of the unit. The field crew found abundant residual coal piles in the area of the Quonset Huts indicating that the quarters were heated with coal burning stoves. The listed strength of the Quartermaster units on December 31, 1943 was 253 men and three officers. Two theater of operation construction storage warehouses were constructed per blueprints in TM 5-280. Eight Cowin Hut warehouses were constructed in the center of the AOC. The foundations of these warehouses are still clearly evident. Figure 4-55 shows J-WH-002 as it appeared during use. The photograph shows that several tents (identified from FM 20-15 as Tent, fire-resistant, pyramidal, M-1934, OD) were used as additional storage near the warehouses. Figure 4-56 is a historical photograph of warehouse J-WH-003. The photograph indicates that the warehouses were heated by fuel burning stoves, as many drums are staged around the structures.

4.9.2 Conceptual Site Model

The CSM forms for AOC J have been updated based in screening and sampling results. The CSM graphic form (Figure 4-57) and figures showing potential release mechanisms and potential receptors (Figures 4-58 and 4-59) are provided in the Figures section at the end of the text. The CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC J included USTs, fuel dispensing activities, vehicles, and drums. Potential release mechanisms included spills, leaks, and direct discharges and burning of materials. The potentially impacted media in AOC J included surface and subsurface soils, groundwater, air, and biota. Arsenic, lead, DRO, and RRO were all detected above PALs in AOC J.

Direct contact by incidental soil ingestion is a complete exposure pathway because contaminants were detected in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because contaminants with the potential of permeating the skin were detected in the soil. Ingestion of groundwater in AOC J is a complete exposure pathway because metal and petroleum contaminants were detected in groundwater. Surface water was not sampled in this AOC.

Ingestion of wild food is a complete exposure pathway because contaminants were detected that have the potential to bioaccumulate and AOC J could be used for hunting and harvesting of wild food. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC J because volatile and petroleum contaminants were detected in the soil in an area within 30 feet of a potential future building location.

4.9.3 Summary of the Screening and Sampling Activities in AOC J

Table 4-26 provides a summary of the screening and sampling activities conducted in AOC J. The site features that had detects by the UVOST system and/or detections in the analytical data above the PAL are discussed in more detail in Sections 4.9.5 and 4.9.6. Maps with the locations of the site features discussed below are provided in Figures J-0 and J-1 in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.9.4.

4.9.4 Deviations to the Work Plan

During the course of the investigation in AOC J, 22 variances from the Work Plan were identified and documented as deviations. A summary of these deviations is provided below and a complete listing is provided in Table 4-27.

There were 22 variances to the work plan in AOC J. One Building Unknown (BU) site feature was identified as having a concrete foundation and still standing walls; features similar to Warehouse (WH) site features. Nineteen additional BU site features were newly identified during the course of field activities. One site feature identified for screening and sampling in the work plan was not screened or sampled because it was in the middle of a road ('right-of-way"). One Unknown (UN) site feature was newly identified during the course of field activities. The feature was square in shape and was bermed on two sides. It was screened and sampled.

4.9.5 UVOST POL Screening Results

Thirty-two site features were screened using UVOST technology in AOC J. A total of 364 boreholes were drilled, totaling 5,592 feet; 45 feet in 10 boreholes was drilled with stainless steel hand augers and the remaining 5,547 feet were drilled with the direct push drill rig. Site features screened with the UVOST are listed in Table 4-28.

As shown in Table 4-26, of the 32 site features screened in AOC J, UVOST screening identified potential contamination at four site features. Details of the investigation of these four site features are described below. In addition to the discussion of the UVOST screening, the detected results of GRO, DRO, and RRO are also discussed.

4.9.5.1 AOC J – Spill 002 (J-SP-002)

The field team identified a pile of contaminated soil at the southeast corner of this site feature. Local Port Heiden residents reported that these soil piles were removed from the nearby Spill 003 during road construction activities. Fourteen screening boreholes were drilled at this site feature with the direct push drill rig. The UVOST locations were identified as 12FMJSP002UV001 through 12FMJSP002UV014. Boreholes were not advanced through the pile in order to avoid carrying the contamination to lower depths. UVOST probe UV014 was advanced at the very edge of the soil pile. Figure 4-60 shows the UVOST screening borehole log for UVOST probe UV014. A waveform typical of surface vegetation is present from 0 to 0.4 feet bgs. Suspected fuel signature was detected at 0.5 to 1.9 feet bgs, with a peak fluorescence of 1.6%. The percent fluorescence is relatively small; however, the waveform is generally consistent with a fuel type waveform. From 2 to 10 feet bgs, the waveform is indicative of uncontaminated subsurface soil. From 10.1 to 11.8 feet bgs, the fluorescence shown is typical with the subsurface paleosol. There were two piles of soil on the surface at J-SP-002 in the southwest section (Figure 4-61). Each pile was approximately 2.5 feet in diameter and 1.5 feet high. The soil piles had a distinct fuel smell and the volume of each pile of soil is less than 1 cubic yard. Screening borehole UV014 was drilled to the southeast of one of the piles. UVOST probes UV010 and UV013 were drilled west and northwest of the pile, respectively. These two probe locations indicated no subsurface contaminant migration in those directions.

Soil sample 12FMJSP002DT001 and duplicate 12FMJSP002DT901 were collected from soil within the one of the pile perimeters. The material was collected from the freshly uncovered soil at the base of the pile at a depth of 1 to 2-feet in order to avoid the portion of the pile that was weathered. In accordance with the ADEC sampling guidance, samples were always collected from a minimum of 0.5 feet in depth. The soil samples were submitted for laboratory analysis of POL suite constituents. DRO was detected at 1,600 mg/kg (PAL= 250 mg/kg) and RRO was detected at 4,000 mg/kg (PAL= 10,000). The location of J-SP-002 is shown on Figure J-1 in Appendix M.

4.9.5.2 AOC J – Spill 003 (J-SP-003)

Thirteen screening boreholes and one butterfly borehole were drilled at this site feature with the direct push drill rig. The UVOST locations were identified as 12FMJSP003UV001 through 12FMJSP003UV013. Figure 4-62 shows the UVOST screening borehole log for UV005. From 0 to 0.6 feet, there is fluorescence typical of surface vegetation; from 0.7 to 9.7 feet bgs, there is a potential fuel signature present with a maximum fluorescence of 7.8%. From 9.8 to 15.8 feet bgs, the waveform is consistent with clean subsurface soil. A butterfly borehole was drilled approximately 1 foot to the southwest and contamination was present at similar depths at similar percent fluorescence. Figure 4-63 shows the screening logs for UV005 and UV005BF plotted side by side.

One soil sample was collected for full suite analysis (12FMJSP003DT001) from a depth of 2 to 3 feet bgs, and one soil sample was collected for POL suite analysis (12FMJSP003DT002 and duplicate 12FMJSP003DT902) near UV005 and UV005BF. These sample locations are shown on Figure J-1 in Appendix M. GRO was qualified as not detected in either soil sample, DRO was detected in the soil samples at concentrations ranging from 7,600 to 13,000 mg/kg (PAL= 250 mg/kg), and RRO was detected at a concentration of 12,000 mg/kg (PAL= 10,000 mg/kg).

The field team collected multiple samples for the correlation study from material hand augered at this location. The team found that the concentration values for contamination decreased significantly within 5 feet laterally of the UVOST probe UV005 location.

The volume of soil exceeding the PALs at this site features was computed utilizing the spatial modeling capabilities found within the ArcGIS version 10.1 software. Data input into the model was the LIF measurements for all of the UVOST probe locations. Supplemental points representing samples that indicated that the soil was below PALs were also included to more accurately limit the spatial extent. Contouring of the area of contamination was undertaken by interpolating UVOST points to contours of LIF values through the inverse distance weighted spatial modeling. Variable parameters were set as follows:

- Output cell size was left as default (1.546337 10^{-6}),
- Exponent of distance was set to a power of 4, and
- Search radius was set to variable (default) utilizing 20 points.

The volume of the soil was then computed by multiplying the thickness of contamination by the computed square footage of the areal extent of the feature that exceeded 1.5%RE above the insitu background of the borehole. The volume of soil computed through this method is 177 cubic yards. The outline of the contaminated soil body is shown graphically on Figure 4-64. The location of site feature J-SP-003 is shown on Figure J-1 in Appendix M.

4.9.5.3 AOC J – Warehouse 002 (J-WH-002)

The project work plan identified three overlapping site features at this location. The field team investigated all of the three indicated features with UVOST probes and samples designated as site feature J-WH-002. The field team noted the presence of stained soil at the south end of the site feature. The impacted area was south of the remaining warehouse foundation in the area of the roadway ramp leading down to the level of the feature. A review of the historical photograph of the feature (Figure 4-55) shows that the access ramp to the feature was located in the southeast corner of the present ground scar. The ramp area is presently filled with soil and is no longer present. It is this fill area that is composed of the contaminated soils, that has a distinct fuel odor when the surface was disturbed. The soil had several small piles incorporated within it which seemed to indicate that the contaminated soil may have been moved at some point in time.

Thirty screening boreholes and three butterfly boreholes were screened with UVOST technology at this combined site feature. All of the boreholes were drilled with the direct push drill rig. The UVOST screening locations were identified as 12FMJWH002UV001 through 12FMJWH002UV030. Figure 4-65 shows the UVOST screening and soil sampling locations at J-WH-002. Figure 4-66 shows the UVOST borehole screening log for UV002BF. From 0 to 0.6 feet bgs, the waveform shows slight fluorescence of surface vegetation (1.5%); from 0.7 to 1.0 feet bgs, there is an area of suspected fuel signature with a waveform that is consistent with a fuel type waveform with a maximum fluorescence of 5.6 %RE and an average fluorescence of 3.5 %RE. From 1.1 to 16.2 feet bgs, the waveform returns to one consistent with clean subsurface soil (0.8% fluorescence).

One soil sample (12FMJWH002DT001) was collected near this UV002BF from a depth of 0.5 to 1 foot bgs. GRO was detected at 0.92 mg/kg (PAL= 300 mg/kg), DRO was detected at 3,200 mg/kg (PAL= 250 mg/kg), and RRO was detected at 12,000 mg/kg (PAL= 10,000 mg/kg).

Figure 4-67 shows the borehole screening log for UV018. From 0 to 1.1 feet bgs, the waveform is typical of surface vegetation. From 1.1 to 2 feet bgs, the waveform is typical of a fuel type waveform and there is a maximum percent fluorescence at 22.3%. From 2.1 to 2.8 feet bgs, the percent fluorescence decreases to 1% but still may represent a fuel type waveform. From to 2.9 to 12.1 feet bgs, the waveform is consistent with fluorescence of clean subsurface soil. A butterfly borehole (UV018BF) was drilled 2.8 feet to the southwest. Figure 4-68 shows the borehole screening logs for UV018 and UV018BF plotted side by side. The contamination was detected at the same depth interval but with less percent reflectance (9.5% vs. 22.3%) in the butterfly borehole UV018BF than in UV018.

Figure 4-69 shows the UVOST borehole screening log for 12FMJWH002UV025. From 0 to 0.8 feet bgs, the waveform is consistent with surface vegetation fluorescence. From 0.9 to 3.8, the waveform is consistent with a suspected fuel signature waveform and there is a peak in percent fluorescence of 6.3%. From 3.9 to 4.7 feet bgs, the waveform is consistent with clean subsurface soil. From 4.8 to 7.7 feet bgs, the waveform is consistent with a fuel type waveform but is slightly different than the waveform from 0.9 to 3.8 feet bgs. This fluorescence has a higher response in the 350 nanometer channel while the contamination above is more responsive in the 400 nanometer channel. Due to the higher response in the lower channel, this contamination appears more blue on the screening log. The contamination over the 4.8 to 7.7 feet bgs zone has a maximum fluorescent at 11.8 %RE. From 7.7 to 11.8 feet bgs, the waveform is consistent with clean subsurface soil. A butterfly borehole (UV025BF) was drilled 0.5 feet east of UV025; contamination was detected at similar depths and at similar percent fluorescence in the butterfly borehole. Figure 4-70 shows UV025 and UV025BF plotted side by side.

One soil sample (12FMJWH002DT003) was collected for full suite analysis from a depth of 3 to 4 feet bgs near screening location UV025. GRO was detected at 11 mg/kg (PAL= 300 mg/kg), DRO was detected at 3,700 mg/kg (PAL= 250 mg/kg), and RRO was detected at 12,000 mg/kg (PAL= 10,000 mg/kg).

Figure 4-71 shows the UVOST screening borehole log for UV026. From 0 to 4.2 feet bgs, the waveform is consistent with a suspected fuel signature, and there is a peak percent fluorescence of 9.4%. From 4.2 to 11.8 feet bgs, the waveform is typical of clean subsurface soil.

The maximum effective LIF was computed for all UVOST probes in the area of site feature J-WH-002 and is plotted on Figure 4-72. The elevated LIF measurements that were taken within the subsurface paleosol or the current surface vegetation were excluded from the maximum values. A data analysis of LIF measurements was also conducted on each 1-foot increment within the UVOST borings. These average effective LIF values by 1-foot increments were then plotted as subsurface "slices" under the feature. These average effective LIF values at specific depths are shown in Figure 4-73. A transect through selected UVOST boreholes is also included as Figure 4-74.

It appeared to the field crew that the contaminated soil was all near surface and was "draped" across the pre-existing feature surface. Contaminated soil was also present in some small surficial soil piles. These observations appear to be more consistent with contaminated soil being placed onto the previous ground surface than being a subsurface release. Small hand excavations at the lateral edges of the warehouse entrance ramp did not indicate that the contamination extended laterally into the subsurface strata.

The volume of soil exceeding the PALs at this site feature was computed utilizing the spatial modeling capabilities found within the ArcGIS version 10.1 software. Data input into the model included the LIF measurements for all of the UVOST probe locations. Supplemental points representing samples that indicated that the soil was below PALs were also included to more accurately limit the spatial extent. Contouring of the area of contamination was undertaken by interpolating UVOST points to contours of LIF values through the inverse distance weighted spatial modeling. Variable parameters were set as follows:

- Output cell size was left as default ($1.546337\ 10^{-6}$),
- Exponent of distance was set to a power of 4, and
- Search radius was set to variable (default) utilizing 20 points.

The volume of the soil was then computed by multiplying the thickness of contamination by the computed square footage of the areal extent of the feature that exceeded 1.5%RE above the insitu background of the borehole. The volume of soil computed through this method is 177 cubic yards. The outline of the contaminated soil body is shown graphically on Figure 4-72. The location of site feature J-WH-003 is shown on Figure J-1 in Appendix M.

4.9.5.4 AOC J – Warehouse 003 (J-WH-003)

Twenty-four screening locations, including one butterfly location, were screened with UVOST technology at this site feature. All 25 screening boreholes were drilled with a direct push drill rig. The screening locations were identified as 12FMJWH003UV001 through 12FMJWH003UV025. Figure 4-75 shows the UVOST screening borehole log for UV001. From 0 to 0.4 feet bgs, the waveform is consistent surface vegetation. From 0.5 to 9.3 feet bgs, the waveform indicates clean soil and subsurface soil. From 9.4 to 11.0 feet bgs, the waveform is generally consistent with a subsurface paleosol, which has a characteristically extremely short duration fluorescence with the highest peak being in the 450 nanometer channel. However, from 11.1 to 12.6 feet bgs, the waveform has possible characteristics of a potential fuel signature waveform combined with the signature from the paleosol. The duration of fluorescence dramatically increases, especially within the 400 nanometer channel. This is evident by the longer "tails" seen on each of the specific wavelength peaks in the callout on the UVOST log. The preponderance of fluorescence also shifts from the 450 to 400 nanometer channels. Both of these changes in the log produce a waveform which is more characteristic of a fuel signature. When this depth interval was sampled, the soil core at the interval contained very little soil. It was organic, vegetative matter (peat) with only a few ½-inch thick layers of fine sands. A butterfly borehole (UV001BF) was drilled 1 foot to the southwest of UV001. A similar waveform to UV001 was detected at a similar depth. Figure 4-76 presents the butterfly plot of UVOST borings UV001 and UV001BF.

Figure 4-77 shows the UVOST screening borehole log of UV002. The 17.1 %RE seen from 0-0.1 foot bgs is clearly the result of fluorescence of surface vegetation. This is evident from the extremely short lived fluorescence with the majority of LIF in the 450 nanometer channel. From 0.1 to 9.1 feet bgs, the waveform is typical of clean subsurface soil. At 9.9 feet bgs, the subsurface paleosol fluorescence appears, and at 10.8 feet bgs, the waveform starts to take on the fuel type waveform until a depth of 11.8 feet bgs, when the paleosol waveform becomes evident. The maximum fluorescence in this interval is 10.5%. The waveform from 10.8 to 11.8 feet appears to be a combination of paleosol and possible fuel signature. This can most easily be observed in the 400 nanometer channel (green) peak callout from this depth. The channel has somewhat longer lived fluorescence than the interval above and below this depth. However, it should be noted that the intensity (height) of the tail is low compared to the overall intensity of the peak within that channel. When evaluating the waveform from this depth compared to the waveform directly above this interval it is quite clear that the main difference is only in the 400 nanometer channel.

Two soil samples were collected at site feature J-WH-003. One soil sample was collected for full suite analysis near screening location UV002 (12FMJWH003DT001) from 10 to 12 feet bgs. The 10- to 12-foot interval in the sample contained very little actual soil but was composed of very organic material (peat) with some fine sands in thin lenses of less than ½-inch in thickness. GRO was detected at 4.8 mg/kg (PAL= 300 mg/kg), DRO was detected at 170 mg/kg (PAL= 250 mg/kg), and RRO was reported well below regulatory levels at 1,500 mg/kg (PAL= 10,000 mg/kg). No fuel odor was detected within the peat layer. However, it should be noted that RRO was elevated within this zone at 1,500 mg/kg and may be the cause of the UVOST spike at that depth. This interpretation is further supported by the total lack of LIF response in the 350 nanometer channel. A larger photograph can also be found in the photograph log as 12FMgeologypic002. See Figure J-1 in Appendix M for screening and sampling locations at J-WH-003.

Figure 4-78 shows the UVOST screening borehole log for UV019. From 0 to 0.2 feet bgs, the waveform is consistent with surface vegetation. From 0.3 to 10.4 feet bgs, the waveform is consistent with clean soil and subsurface soil. At 10.4 feet bgs, the subsurface paleosol fluorescence appears, and at 12.4 feet bgs, a waveform that is likely trace contamination in a very clean, organic, rich paleosol layer is present. From 13.6 to 16.0 feet bgs, the waveform is consistent with clean subsurface soil again.

Figure 4-79 shows the screening borehole log for UV020. From 0 to 0.5 feet bgs, the waveform is consisting with surface vegetation. From 0.6 to 9.7 feet bgs, the waveform is consistent with clean subsurface soil. At 9.8 feet bgs, the subsurface paleosol is present and at 11.9 feet bgs; a suspected fuel signature is present with a 10.5% fluorescence. The suspected contamination interval is present from 11.9 to 12.6 feet bgs, tapering back to paleosol at 12.7 to 15.7 feet bgs, and then clean subsurface soil to a total depth of 15.8 feet bgs.

Figure 4-80 shows the screening borehole log for UV021. From 0 to 0.3 feet bgs, the waveform is consistent with surface vegetation. From 0.4 to 9.9 feet bgs, the waveform is consistent with clean subsurface soil. At 10 feet bgs, the subsurface paleosol is present with suspected contamination present from 12.2 to 12.6 feet bgs. The callout for the interval from 10 feet to 12.2 feet bgs is an exceptional example of the paleosol LIF signature. All channel peaks are very short lived as indicated by their extremely and unusually narrow width. The proportional response between channels is absolutely typical of vegetation seen on the surface or known paleosol layers in the subsurface. The highest intensity is seen in the 450 nanometer channel with somewhat lower intensity in the 400 and 500 nanometer channels. The 350 nanometer channel is proportionally nearly nonexistent. This LIF waveform can then be compared to the waveform found directly below it at the 12.2 to 12.6 depth. The lower waveform is nearly a duplicate of the paleosol waveform with the notable exception of the 400 nanometer channel. The potential fuel signature shows a longer tail in this channel as well as a disproportional intensity of the 400 nanometer channel when compared to the straight paleosol or vegetative mat waveforms. The paleosol is again present at 12.7 to 15.2 feet bgs, and the remaining length of the boring log shows clean subsurface soil to a total depth of 19.7 feet bgs.

Steep sidewalls made drilling to the northeast and southwest problematic. Boreholes at a greater distance in these two directions do provide some limit to the lateral extent of contamination. The highest LIF measurements within this contamination zone do not exceed PALs and so therefore the limited extent closure data to the west is not considered problematic.

The maximum effective LIF was computed for all UVOST probes in the area of site feature J-WH-003 and is plotted on Figure 4-81. The elevated LIF measurements that were taken within the subsurface vegetative mat or the current surface vegetation were excluded from the maximum values. A data analysis of LIF measurements was also conducted on each 1-foot increment within the UVOST borings. These average effective LIF values by 1-foot increments were then plotted as subsurface “slices” under the feature. The vegetative mat at approximately 12 feet bgs exhibited very high LIF values. An examination of soil borings in the feature showed this material to be composed of nearly soil free vegetative mat. These average effective LIF values after removal of natural LIF at specific depths are shown in Figure 4-82. A transect through selected UVOST boreholes is also included as Figure 4-83. UVOST screening locations at this site feature are shown on Figure J-1 in Appendix M.

4.9.6 Soil Sampling Results

Twenty-eight full suite primary soil samples, 16 POL suite primary soil samples, nine PCB primary soil samples, and one metals only soil sample were collected from 26 site features in AOC J for analytical laboratory analysis. The type and number of site features where full suite, POL suite, and PCB soil samples were collected are listed in Table 4-29.

Samples were generally collected from screening locations that indicated possible presence of subsurface contamination using UVOST screening. If there was no contamination indicated with the UVOST, then a sample was taken at a random location located within the site feature and the sample collected from either near the surface, or near the groundwater interface.

Four site features had contaminants detected above project action limits – J-PR-001, J-SP-002, J-SP-003, and J-WH-002. Contaminants detected above the PALs include DRO (1,500 to 12,000 mg/kg, PAL= 250 mg/kg), RRO (12,000 to 14,000 mg/kg, PAL= 10,000 mg/kg), arsenic (14 mg/kg, PAL= 7.05 mg/kg), and lead (4,300 mg/kg, PAL= 400 mg/kg). The following sections provide a discussion by site feature of the sample results that exceed the project action limits.

4.9.6.1 AOC J – Power House 001 (J-PR-001)

The field team observed that the site of the former power house was now an approximately 6 feet deep depression. A soil sample was collected from a borehole drilled just outside of the depression. The borehole was advanced to a depth deeper than the bottom of the feature pit in order to sample at a relevant depth. The pit was inaccessible to the drilling rig. An attempt was made to sample from the piezometric smear zone in order to evaluate any contamination from the feature that may have accumulated at the smear zone. One soil sample (12FMJPR001DT010) was collected for full suite analysis near the center of the feature from a depth of 14 to 16 feet bgs. Arsenic was detected at 14 mg/kg, above the PAL for arsenic in subsurface soil of 7.05 mg/kg. The sample location and a list of detected contaminants is shown on Figure J-0 in Appendix M.

4.9.6.2 AOC J – Spill 002 (J-SP-002)

One soil sample was collected for full suite analysis (12FMJSP002DT001) near screening borehole UV014 from a depth of 1 to 2 feet bgs. The sample and duplicate 12FMJSP002DT901 were collected from soil within one of the pile perimeters. The material was collected from the freshly uncovered soil at the base of the pile at a depth of 1 to 2-feet in order to avoid the portion of the pile that was weathered. In accordance with the ADEC sampling guidance, samples were always collected from a minimum of 0.5 feet in depth. DRO was detected at 1,500 mg/kg (PAL= 250 mg/kg). See Figure J-1 in Appendix M for soil sampling locations and a list of detected contaminants. See Appendix A for a complete listing of detected contaminants.

4.9.6.3 AOC J – Spill 003 (J-SP-003)

One soil sample was collected for full suite analysis (12FMJSP003DT001) near screening borehole UV005 from a depth of 2 to 3 feet bgs where DRO was detected at 7,600 mg/kg (PAL= 250 mg/kg). A second soil sample was collected (12FMJSP003DT002) for POL analysis 7.5 feet west of screening borehole UV005 from a depth of 2 to 4 feet bgs. DRO was detected at 12,000 mg/kg and RRO was detected at 12,000 mg/kg (PAL= 10,000 mg/kg). The sample collection points were chosen at these location because UVOST probe UV005 exhibited elevated LIF measurements at this depth. See Figure J-1 in Appendix M for soil sampling locations. See Appendix A for a listing of detected soil sample results.

4.9.6.4 AOC J – Warehouse 002 (J-WH-002)

Three soil samples were collected for full suite analysis (12FMJWH002DT001, 12FMJWH002DT002, and 12FMJWH002DT003), one soil sample was collected for POL analysis (12FMJWH002DT004), and one soil sample was collected for metals analysis (12FMJWH002DT005). See Figure J-1 in Appendix M for soil sampling locations and a list of detected contaminants.

12FMJWH002DT001 was collected near screening borehole UV002, from a depth of 0.5 to 1 feet bgs based upon elevated LIF at that depth in the UVOST probe. Additionally, the field crew noted petroleum odor in soil at that location. DRO was detected at 3,200 mg/kg (PAL= 250 mg/kg) and RRO was detected at 14,000 mg/kg (PAL= 10,000 mg/kg). 12FMJWH002DT003 was collected near UV025 from a depth of

3 to 4 feet bgs. DRO was detected at 3,700 mg/kg and RRO was detected at a concentration of 12,000 mg/kg. 12FMJWH002DT005 was collected 0.5 to 1 feet bgs in an area that had debris on the surface. The field team identified the debris as fragments of a non-modern lead-acid storage battery. Lead was detected at 4,300 mg/kg (PAL= 400 mg/kg).

4.9.7 Groundwater Results

Four groundwater monitoring wells (J-MW-001, J-MW-002, J-MW-003, and J-MW-004) and three piezometers (J-PZ-001, J-PZ-002, and J-PZ-003) were installed in AOC J. One primary groundwater sample was collected for full suite analysis from each of the four groundwater wells (12FMJMW001GW001, 12FMJMW002GW001, 12FMJMW003GW001 and 12GMJMW004GW001); additionally, one groundwater sample was collected, filtered, and submitted for metals analysis from each monitoring well. Arsenic, iron, cobalt, lead, and manganese were each detected above project action limits. See Appendix A for a list of detected groundwater sample results and Figure J-1 in Appendix M for the location of the monitoring wells. The following sections provide a discussion of the groundwater sample results by well that exceeded project action limits.

4.9.7.1 Groundwater Monitoring Well J-MW-002

Groundwater monitoring well J-MW-002 is located at site feature J-WH-002. One primary groundwater sample (12FMJMW002GW001) was collected and submitted for full suite analysis. Cobalt, iron, and manganese were detected above project action limits. Cobalt was detected at 6.7 µg/L (PAL= 4.7 µg/L), iron was detected at 18,000 µg/L (PAL= 11,000 µg/L), and manganese was detected at 370 µg/L (PAL= 320 µg/L).

4.9.7.2 Groundwater Monitoring Well J-MW-003

Groundwater monitoring well J-MW-003 is located at site feature J-WH-003. One primary groundwater sample (12FMJMW003GW001) was collected for full suite analysis. Arsenic was detected at 11 µg/L (PAL= 10 µg/L), cobalt was detected at 12 µg/L (PAL= 4.7 µg/L), iron was detected at 46,000 µg/L (PAL= 11,000 µg/L), lead was detected at 24 µg/L (PAL= 15 µg/L), and manganese was detected at 420 µg/L (PAL= 320 µg/L).

4.9.8 Geophysical Survey Results

A geophysical survey was not conducted in AOC J.

4.9.9 Risk Evaluation for Soils in AOC J

Arsenic was the only risk-contributing COC in AOC J soil samples. The maximum concentration of 14 mg/kg detected in the AOC J equates to the ILCR of 3×10^{-5} and the HI of 0.6. However, as discussed in Section 3.12.2, arsenic is determined to be naturally occurring; hence, excluded from risk quantification. With the exclusion of arsenic, there is no calculable risk for AOC J.

As for the non-risk-contributing COCs, lead was detected above the background and the ADEC PAL in one out of 36 soil samples. The petroleum fraction DRO was detected in 60 of 64 soil samples with 10 samples exceeding the PAL, while RRO was detected in 28 of 64 samples with 11 samples exceeding the PAL.

No further action is necessary for AOC J soil from a risk perspective; however, the DRO, RRO, and one exceedance of lead would need to be addressed with respect to the ADEC PALs.

4.9.10 Summary of the RI in AOC J

A total of 68 site features were identified for investigation in AOC J. Thirty-two site features were screened by the UVOST. A total of 364 boreholes were drilled, totaling 5,592 feet. Of the 32 site features screened, the UVOST detected potential subsurface contamination at four site features – two spill sites (J-SP-002 and J-SP-003) and two warehouses (J-WH-002 and J-WH-003).

Modeling with the ArcGIS software indicates that approximately 177 cubic yards of soil is contaminated above PALs at site feature J-SP-003 and 131 cubic yards at site feature J-WH-002.

Twenty-six site features were sampled; 28 soil samples were collected for full suite analysis, 16 soil samples were collected for POL suite analysis, nine soil samples were collected for PCB analysis and one soil sample for metals analysis. Four site features had contaminants detected above the PALs – J-PR-001, J-SP-002, J-SP-003, and J-WH-002. Contaminants detected above PALs include DRO (1,500 to 12,000 mg/kg, PAL= 250 mg/kg), RRO (12,000 to 14,000 mg/kg, PAL= 10,000 mg/kg), arsenic (14 mg/kg, PAL= 7.05 mg/kg), and lead (4,300 mg/kg, PAL= 400 mg/kg).

Four groundwater monitoring wells and three piezometers were installed in AOC J. The location of these wells and piezometers are shown of Figure J-1 in Appendix M. Four groundwater samples were collected; one from each well for full suite analysis and filtered metals. Monitoring wells J-MW-002 and J-MW-003 had detections of cobalt (6.7 to 12 µg/L, PAL= 4.7 µg/L), arsenic (11 µg/L, PAL= 10 µg/L), iron (18,000 to 46,000 µg/L, PAL= 11,000 µg/L), lead (24 µg/L, PAL= 15 µg/L), and manganese (370 to 420 µg/L, PAL= 320 µg/L) above the PALs.

No geophysical surveys were conducted within AOC J.

4.9.11 Data Gaps

No data gaps were identified during the investigation of this AOC.

4.10 AOC K

The field investigation in AOC K was conducted August 27, 2012 through October 5, 2012. Seventy-seven site features were identified for investigation in AOC K (see Table 4-1). Thirty-four site features were screened with UVOST technology in AOC K and soil samples were collected from 23 site features (see Table 4-2). Three groundwater monitoring wells and two piezometers were installed in AOC K.

The history of AOC K, an updated CSM form, and the results of the field investigation in AOC K are presented below. Maps with the actual screening and sampling locations and a listing of detected contaminants are provided on Figure K-0 in Appendix M. Photographs of each site feature are provided in Appendix N.

4.10.1 Historical Use of AOC K Area

The Bush Report (Bush, 1944) and the Fort Morrow Operations Map (AGC, 2010) indicate that AOC K was used by Battery A of the 209th Field Artillery. The approximately 492-acre area contained multiple Quonset huts, latrines, a shower, a mess hall, three recreation buildings, and many other typical Army garrison structures. The latrines, unlike those in AOC C, appear to have been pit type latrines. This is consistent with TM 5-280, as separate shower buildings were constructed for areas utilizing pit type latrines. Coal was found in the eastern and southeastern portions of the AOC but was not observed in the main garrison area. The strength of the 209th as of December, 1942 was listed as 96 men and four officers.

4.10.2 Conceptual Site Model

The CSM forms for AOC K have been updated based on screening and sampling results. The CSM graphic form (Figure 4-84) and figures showing potential release mechanisms and potential receptors (Figures 4-85 and 4-86) are provided in the Figures section at the end of the text. The CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC K included USTs, ASTs, fuel dispensing activities, vehicles, and drums. Potential release mechanisms included spills, leaks, and direct discharges. The potentially impacted media in AOC K include surface and subsurface soils, groundwater, air, and biota. There were no COCs detected above the PALs in AOC K.

Direct contact by incidental soil ingestion is a complete exposure pathway because metal and petroleum contaminants were detected in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because contaminants with the potential of permeating the skin (arsenic) were detected in the soil. Ingestion of groundwater in AOC K is a complete exposure pathway because groundwater was found to have low levels of metal contaminants and could be used as a drinking water source. Surface water was not sampled in this AOC.

Ingestion of wild food is a complete exposure pathway because contaminants were detected that have the potential to bioaccumulate and AOC K could be used for hunting and harvesting of wild food. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC K because volatile and petroleum contaminants were detected in the soil in an area within 30 feet of a potential future building location.

4.10.3 Summary of the Screening and Sampling Activities in AOC K

Table 4-30 provides a summary of the screening and sampling activities conducted in AOC K. The site features that had detections by the UVOST system and/or detections in the analytical data above the PALs are discussed in more detail in Sections 4.10.5 and 4.10.6. Maps with the locations of the site features discussed below are provided on Figure K-0 in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.10.4.

4.10.4 Deviations to the Work Plan

During the course of the investigation in AOC K, 7 variances from the Work Plan were identified and documented as deviations. A summary of these deviations is provided below and a complete listing of the deviations is provided in Table 4-31.

There were seven variances to the work plan in AOC K. The Recreation (RC) site feature selected for screening and sampling in the work plan was inaccessible to the drill rig. It was not screened or sampled, however, the two RC site features not identified for screening and sampling in the work plan were screened and sampled in its place. Two Quarters (QT) site features were screened in addition to the three QT site features identified in the work plan. Two site features identified as Ground Scars (GS) were determined to be rectangular in shape and have berms on all four sides; features consistent with possible fuel storage activities. One of these site features was screened and sampled and the other was only screened.

4.10.5 UVOST POL Screening Results

Thirty-four site features were screened using UVOST technology in AOC K. A total of 182 screening boreholes were drilled, totaling 3,094 feet; 460 feet in 29 boreholes were drilled with a stainless steel hand auger, and the remaining 2,634 feet were drilled with a direct push drill rig. The site features screened with the UVOST are listed in Table 4-32.

As shown in Table 4-30, of the 34 site features screening in AOC K, potential contamination was identified at one site feature – storage area 001 (K-ST-001). Details of the investigation of this site feature are described below. In addition to the discussion of the UVOST screening, the detected results of GRO, DRO, and RRO are also discussed.

4.10.5.1 AOC K – Storage 001 (K-ST-001)

Seven screening boreholes and one butterfly borehole were drilled at this site feature. The UVOST screening locations were identified as 12FMKST001UV001 through 12FMKST001UV007. Figure 4-87 shows the UVOST screening borehole log for UV003. There is a distinct fuel signature waveform from 0 to 2.8 feet bgs, with peak fluorescence at 9.8%. From 2.9 to 4.7 feet bgs, a waveform typical of clean subsurface soil is indicated. From 4.8 to 8.6 feet bgs, there is a waveform typical of a subsurface paleosol, and from 8.7 to 19.9 feet bgs, the waveform is typical of clean subsurface soil. A butterfly screening borehole was drilled (UV003BF) approximately 2.2 feet to the south of UV003. The suspected contamination was not detected in the butterfly borehole (see Figure 4-88); however, the depths of the clean subsurface soil and subsurface paleosol were found to be at similar depths.

The field team attempted to collect soil material for the POL/UVOST LIF correlation evaluation from this site feature on September 4, 2013. The field team hand augered several boreholes near UV003 but were unable to find sufficient variability in soil concentrations to conduct the evaluation. The field team did note that the soil had a distinct fuel odor and staining within a short distance of the UVOST probe but that the contamination did not extend laterally to a sufficient distance to warrant additional sampling.

One soil sample was collected for full suite analysis (12FMKST001DT001) from a sample borehole located approximately 1.5 feet to the northeast from screening location UV003 from a depth of 1.5 to 2 feet bgs. GRO was detected at 0.89 mg/kg (PAL= 300 mg/kg), DRO was detected at 43 mg/kg (PAL= 250 mg/kg), and RRO was qualified as not detected.

The contamination detected is likely above PALs based on the %RE of 9.8. The lateral extent of the contamination is bounded by the other 6 UVOST probes advanced at the feature. See Figure K-0 in Appendix M for the UVOST probe locations. Additionally, the contamination is bounded 2.2 feet to the south by UV003BF, 1.5 feet to the northeast by the sample borehole DT001, and to the west by multiple boreholes installed by the field team attempting to collect correlation sample material. The largest possible volume of contaminated soil therefore becomes a cylinder of soil approximately 3 feet in diameter by a depth of approximately 3 feet. This results in a maximum computed volume of 0.75 cubic yard of contaminated soil.

The chemical nature of the contamination is not accurately known as the sample borehole did not capture the highest contaminant levels. This contamination appears to be diesel fuel or heating oil based upon the ratios of POL components observed in the sample collected.

4.10.6 Soil Sampling Results

Twenty-three full suite primary soil samples, one POL suite primary soil sample, and three PCB primary soil samples were collected from 23 site features in AOC K for analytical laboratory analysis. The type and number of site features where full suite, POL suite, and PCB samples were collected are listed in Table 4-33.

There were no detects above PALs in the soils sampled in AOC K.

It is likely that soils within site feature K-ST-001 exceed the PAL for DRO.

4.10.7 Groundwater Results

Three groundwater monitoring wells (K-MW-001, K-MW-002, and K-MW-003) and two piezometers (K-PZ-001 and K-PZ-002) were installed in AOC K. A groundwater sample was collected from each of the three monitoring wells (12FMKMW001GW001, 12FMKMW002GW001, and 12FMKMW003GW001); an additional groundwater sample was collected, filtered, and submitted for metals only analysis from each well. There were no detections above the PALs in any of the groundwater samples.

4.10.8 Geophysical Survey Results

A geophysical survey was not conducted in AOC K.

4.10.9 Risk Evaluation for Soils in AOC K

There are no risk-contributing or petroleum hydrocarbon COPCs in AOC K soil. No further action is necessary for the AOC K soil.

4.10.10 Summary of the RI in AOC K

Thirty-four site features were screened with UVOST technology in AOC K. A total of 182 screening boreholes were drilled, totaling 3,094 feet. Of those 34 site features screened, one site feature showed the presence of possible subsurface contamination.

Twenty-three soil samples were collected for full suite analysis, one soil sample was collected for POL analysis, and three soil samples were collected for PCB analysis from 23 site features in AOC K. There were no detections above project action limits in AOC K.

Three groundwater monitoring wells and two piezometers were installed in AOC K. All three monitoring wells were sampled for full suite analysis and for filtered metals. There were no detections above project action limits in groundwater in AOC K.

A geophysics survey was not conducted in AOC K.

4.10.11 Data Gaps

The following item presents a potential data gap in AOC K:

- The maximum concentration of DRO contamination identified in site feature K-ST-001 is not accurately known.

4.11 AOC L

The field investigation in AOC L was conducted from August 13, 2012 through October 5, 2012. Forty-four site features were identified for investigation in AOC L (see Table 4-1). Twelve site features were screened with UVOST technology and soil samples were collected at six site features (see Table 4-2). Two groundwater monitoring wells and four piezometers were installed in AOC L.

The history of AOC L, an updated CSM, and the results of the investigation of AOC L are presented below.

4.11.1 Historical Use of the AOC L Area

The weapons company, Company "D" 53rd Infantry Regiment (6-81 mm mortars, 8-30 caliber machine guns, 1-50 caliber machine gun), was discussed in the Bush Report (Bush, 1944) and located at Area Number 3. This area roughly corresponds to the southern limit of AOC L. The heavy weapons company typically had more vehicles than other infantry companies within the regiment.

The field team found that the ground scars in AOC L were slightly narrower than the ground scars in other AOCs. The ground scars in AOC L were deeply dug in and averaged approximately 12 to 14 feet in width. The other ground scars and scars of known Quonset huts were approximately 16 feet or greater in width.

The team also found abundant double-notched 24-inch tent stakes surrounding many of the ground scars. Other ground scars had buried dead-men anchors with wires for attachment of tent guy lines. A review of FM 20-15, "Tents and Tent Pitching" (War Department, 1945) from the World War II era indicates that a "Tent, Fire-Resistant, Wall, Large, OD" was of the appropriate size for the observed ground scars. The field crew found abundant evidence of coal in the areas surrounding the garrison area, which would indicate that these tents were equipped with coal burning stoves.

Therefore, the only release mechanism for fuels in this approximately 1,129-acre area would likely be from vehicles, as heating was produced from coal burning stoves.

4.11.2 Conceptual Site Model

The CSM forms for AOC L have been updated based on screening and sampling results. The CSM graphic form (Figure 4-89) and figures showing potential release mechanisms and potential receptors (Figures 4-90 and 4-91) are provided in the Figures section at the end of the text. The CSM scoping form is provided in Appendix L.

Potential sources of contamination in AOC L included fuel dispensing activities, vehicles, and drums. Potential release mechanisms included spills, leaks, and direct discharges. The potentially impacted media in AOC L included surface and subsurface soils, groundwater, air, and biota. There were no COCs detected above the PALs in AOC L.

Direct contact by incidental soil ingestion is a complete exposure pathway because volatile and metal contaminants were detected in the soil between 0 and 15 feet bgs. Dermal absorption of contaminants is a complete exposure pathway because arsenic, which has the potential of permeating the skin, was detected in the soil. Ingestion of groundwater in AOC L is a complete exposure pathway because low levels of metal contaminants were detected in groundwater and groundwater could be used a source of drinking water. Surface water was not sampled in this AOC.

Ingestion of wild food is a complete exposure pathway because contaminants were detected that have to potential to bioaccumulate and AOC L could be used for hunting and harvesting of wild food. Inhalation of outdoor air is a complete exposure pathway because volatile and petroleum contaminants were detected between 0 and 15 feet bgs. Inhalation of indoor air, or vapor intrusion, is a complete pathway in AOC L because volatile and petroleum contaminants were detected in the soil in an area within 30 feet of a potential future building location.

4.11.3 Summary of the Screening and Sampling Activities in AOC L

Table 4-34 provides a summary of the screening and sampling activities conducted in AOC L. The site features, which had detects by the UVOST system and/or detections in the analytical data above the PAL, are discussed in more detail in Sections 4.11.5 and 4.11.6. Maps with the locations of the site features discussed below are provided on Figure L-0 in Appendix M. Deviations to the technical approach in the Work Plan are discussed in Section 4.11.4.

4.11.4 Deviations to the Work Plan

During the course of the investigation in AOC L, six variances from the Work Plan were identified and documented as deviations. A summary of these deviations is provided below and a complete listing of deviations is provided in Table 4-35.

There were six variances to the work plan in AOC L. It was determined that two site features listed in AOC L actually were located in AOC K. They were re-named and treated as AOC K site features. Two site features not originally selected for screening and sampling were screened and sampled in lieu of the two site features relocated to AOC K. One additional Building Unknown site feature was screened and sampled because it was determined in the field that it looked more "man-made" than the Building Unknown site feature which was selected for screening and sampling. One Building Unknown site feature which was selected for screening and sampling looked more like a natural feature and not like a "man-made" site feature. It was still screened and sampled.

4.11.5 UVOST POL Screening Results

Twelve site features were screened using UVOST technology in AOC L. A total of 115 UVOST boreholes were drilled, totaling 1,854 feet; 236 feet in 30 boreholes were drilled with stainless steel hand augers, and the remaining 1,618 feet drilled with the direct push drill rig. Site features screened with the UVOST are listed in Table 4-36.

As shown in Table 4-34, UVOST screening did not identify potential contamination in any of the 12 site features screened in AOC L.

4.11.6 Soil Sampling Results

Six soil samples were collected for full suite analysis, and one soil sample was collected for POL analysis in AOC L from six site features, as shown in Table 4-37.

There were no contaminant detections above regulatory levels in AOC L.

4.11.7 Groundwater Results

Two groundwater monitoring wells (L-MW-001 and L-MW-002) and four piezometers (L-PZ-001, L-PZ-002, L-PZ-003, and L-PZ-004) were installed in AOC L. Groundwater samples (12FMLMW001GW001 and 12FMLMW002GW001) were collected from each monitoring well for full suite analysis and an additional groundwater sample was collected, filtered, and submitted for metals only analysis from each monitoring well. There were no detections above project action limits in the sampled groundwater.

4.11.8 Geophysical Survey Results

A geophysical survey was not conducted in AOC L.

4.11.9 Risk Evaluation for Soils in AOC L

There are no risk-contributing or petroleum hydrocarbon COPCs in AOC L soil. No further action is required for the AOC L soil.

4.11.10 Summary of the RI in AOC L

Twelve site features were screened with UVOST technology in AOC L. A total of 115 screening boreholes were drilled, totaling 1,854 feet. Screening by the UVOST did not indicate the presence of subsurface contamination at any of the site features.

Six soil samples were collected for full suite analysis and one soil sample was collected for POL suite analysis from six site features. There were no contaminants detected above project action limits in AOC L.

Two groundwater monitoring wells and four piezometers were installed in AOC L. Groundwater samples were collected for both full suite analysis and metals only analysis from both groundwater monitoring wells. There were no detections above PALs in groundwater in AOC L.

A geophysical survey was not conducted in AOC L.

4.11.11 Data Gaps

No data gaps were identified during the investigation conducted in this AOC.

4.12 Additional Geophysical Surveys

During the 2012 RI, additional geophysical surveys were conducted at seven site features in AOC B:

- AOC B – Mounded Material 002 (B-MM-002),
- AOC B – Mounded Material 003 (B-MM-003),
- AOC B – Dump Site 001 (B-DS-001),
- AOC B – Dump Site 002 (B-DS-002),
- AOC B – Mess Hall 001 (B-MH-001),
- AOC B – Latrine 001 (B-LT-001), and
- AOC B – Quarters 043 (B-QT-043).

Each site feature had a 60-foot × 60-foot grid screened by the EM-61 metal detector.

Two 30-foot × 60-foot grids were screened at B-MH-001 where the as-built diagrams of the mess hall indicated the likely presence of a buried tank.

4.12.1 AOC B – Mounded Material 002 (B-MM-002)

This site feature had relatively low EM61 maximum (or peak) values. The background cut-off value is 5-mV in the color contour maps for this survey area. The data indicate that the higher value data anomalies are relatively low data values and produce sharp peaks in data profiles. The higher data values within this grid are interpreted to be associated with either small pieces of surface or shallow buried metal (Figure P-11 in Appendix P).

4.12.2 AOC B – Mounded Material 003 (B-MM-003)

This site feature had relatively low EM61 maximum (or peak) values. The background cut-off value is 5-mV in the color contour maps for these grids. The data indicate that the higher value data anomalies are relatively low data values and produce sharp peaks in data profiles. The higher data values within this grid are interpreted to be associated with either small pieces of surface or shallow buried metal (Figure P-12 in Appendix P).

4.12.3 AOC B – Drum Storage 001 (B-DS-001)

The linear anomaly in the southern portion of this grid is associated with a utility conduit adjacent to the gravel road. The single higher data value anomaly (peak value of 216-mV) located in the northeast portion of the survey area is interpreted to be associated with a potential valve or junction of pipelines. The pipelines are the linear features (in green) aligned through the high data anomaly (magenta) that are oriented northwest-southeast and another starting at the high data anomaly and oriented north-south. A single lower data value anomaly (53-mV) is interpreted to be associated with a small piece of shallow buried metal (Figure P-13 in Appendix P).

4.12.4 AOC B – Drum Storage 002 (B-DS-002)

This site feature had relatively low EM61 maximum (or peak) values. The background cut-off value is 5-mV in the color contour maps for this survey area. The data indicate that the higher value data anomalies within each of the grids are relatively low data values and produce sharp peaks in data profiles. The higher data values within this grid are interpreted to be associated with either small pieces of surface or shallow buried metal (Figure P-14 in Appendix P).

4.12.5 AOC B – Mess Hall (Left) (B-MH-001)

The highest data value anomaly (magenta color with peak value of 397 mV) in this survey area (30-feet × 60-feet) is interpreted to be a shallow buried piece of metal or a small tank. The smaller anomaly in the northern portion of this grid (magenta color with a peak value of 160-mV) is interpreted to be either a shallow buried small piece of metal or piping. The green color contours may indicate some piping starting at the central anomaly and oriented north-south. Additionally, the EM data may indicate another pipeline oriented northwest-southeast oriented along the northwestern corner of this grid. If the linear orientations of the green and red contours are associated with piping, they may intersect at the smaller high data anomaly (magenta color) in the northern portion of the grid (Figure P-15 in Appendix P).

4.12.6 AOC B – Mess Hall (Right) (B-MH-001)

The highest data value anomaly (magenta color with peak value of 83-mV) is located in the northeast corner of the survey area. This anomaly is interpreted to be associated with a shallow buried piece of metal. The linear shaped, higher data value anomaly (maximum peak value of 70-mV) that is oriented east-west and located in the northwest corner of the grid is interpreted to be associated with a pipeline. All of the other smaller data anomalies (magenta color with peak values ranging from 20-mV to 70-mV) are interpreted to be associated with shallow buried pieces of metal (Figure P-16 in Appendix P).

4.12.7 AOC B – Mess Hall (Outfall) (B-MH-001)

Figure P-17 in Appendix P shows a linear ferrous anomaly, possibly a pipe, running east-to-west near the top of the grid. An additional reconnaissance grid was screened to the east of B-MH-001 to determine where the pipe originated and terminated. Both the EM-61 reconnaissance and tracing by the Shonstedt showed the likely pipe going through the center of B-MH-001 to the southeast. The mess hall in AOC B was screened because it was near as-built condition; there were no signs of excavation near it. In contrast, the mess halls in AOCs C and K did show signs of excavation near where the underground tanks would have been.

4.12.8 AOC B – Latrine 001 (B-LT-001)

The highest data value anomaly (magenta color with peak value 1326-mV) in the north central portion of the grid is interpreted to be associated with a buried tank or larger mass of buried metal and potential remnants of buried piping that may not have been removed. All of the other data anomalies located on the eastern and western edges of the grid (magenta color) range in value from 390-mV to 786-mV. These anomalies are sharp peaked and interpreted to be associated with either shallow buried pieces of metal or remnants of smaller diameter piping that have not been removed (Figure P-18 in Appendix P).

4.12.8.1 AOC B – Quarters 43 (B-QT-43)

The highest data value anomaly (magenta color with peak value of 466-mV) is located in the center of the survey area. This could be associated with a single buried drum, small tank, or a larger piece of scrap metal. The anomaly to the northeast (magenta color) of the central anomaly appears to be made up of two (2) separate anomalies; 1) the furthest northern peak value (255-mV) produces a sharp peak, 2) while the second anomaly (to the southeast) is of lower peak value (194-mV) and produces a more gradual or “rounded” peak. These anomalies are interpreted to be associated with buried pieces of metal, one deeper buried than the other. All of the smaller data anomalies (magenta color with peak data values ranging from 77-mV to 143-mV) are sharp peaked and interpreted to be associated with small, shallow buried pieces of metal, piping remnants, or surface metal. However, no large pieces of surface metal were observed, and no other small pieces of surface metal were noted (Figure P-19 in Appendix P).

4.13 Waste Management

4.13.1 Investigation Derived Waste (IDW) Management

Investigation derived waste (IDW) generated during the project was handled in accordance with the approved Work Plan and applicable federal, state, and local regulations. The waste generated during field activities included solid and liquid IDW, disposable sampling equipment, personal protective equipment (PPE), and general trash. Waste minimization techniques were employed where possible to reduce the quantity of waste generated.

4.13.2 Solid IDW

Soil IDW from boreholes was segregated and bagged by borehole. The point of origin was marked on each bag and the bags were stored in 55-gallon steel drums and staged in a secure location. IDW generated from soil cuttings were characterized using the data collected from the associated borehole. The analytical results were reviewed and the waste was characterized per the project action levels included in the Work Plan and applicable federal and state regulations.

If the results of soil boring samples indicate that the soil met the PALs, the soil was spread on the ground at the point of origin. If the analytical results indicated that the soil cuttings exceeded the PALs, or if analytical results were not received by the time of demobilization from the site, the soil was containerized in labeled 55-gallon drums and staged on-site at a secure location. Based on analytical data received, soil that meets PALs will be ground spread at the point of origin in August of 2013. Soil from site features with detections above the PALs will be transported off site in properly labeled DOT approved containers for disposal at a DEC approved facility. Approximately one 55-gallon drum of residual sampling soil was generated from boreholes which exceeded the PALs.

Disposable sampling equipment, PPE, and general trash were contained in sealed plastic bags and disposed of as non-hazardous solid waste at the Port Heiden municipal landfill. The exception to this was waste generated during PCB sampling activities in areas known to have had PCB contamination. This IDW were containerized separately and managed until analytical sample results were received and reviewed. Since the results of the PCB soil data indicated no exceedances to the project action limit of 1 mg/kg, this solid IDW was disposed of at the Port Heiden municipal landfill.

4.13.3 Liquid IDW

Liquid IDW generated from equipment decontamination and groundwater monitoring well purging and development activities was containerized in 55-gallon drums, placed in 85-gallon over pack containers, and segregated by AOC. Samples were collected of the decontamination water for laboratory analysis of GRO, DRO, RRO, VOCs, SVOCs, metals, and PCBs to determine appropriate waste transportation and disposal requirements. IDW generated from monitoring well development/purging activities were characterized using the data collected from the associated monitoring well.

Groundwater well development or purge water sample results were not received prior to demobilization from the site. The water was stored in 55-gallon drums inside 85-gallon over packs in a secure location. Groundwater that meets the PALs will be discharged to the ground surface in August 2013. Groundwater that exceeds these values for petroleum constituents will be processed through a GAC filter and discharged to the ground surface. Groundwater that exceeds the PALs for non-petroleum constituents will be transported off-site for disposal at an approved facility.

The analytical results of the decontamination water samples were reviewed and the waste was characterized per the project action levels included in the Work Plan and applicable federal and state regulations. Following completion of a waste determination, the IDW containers were labeled and marked as appropriate. Table 4-38 shows decontamination water results that exceeded the PALs. Appendix B contains the complete listing of the analytical results for the decontamination water samples. The decontamination water that met the PALs was discharged within the AOC of origin. Decontamination water that exceeded the PALs for organic constituents (AOC C and AOC D) was processed through a GAC filter and discharged to the ground surface near the point of origin. Decontamination water from AOC K was consumed in sampling.

4.13.4 Petroleum Releases

On September 15, 2012, approximately 1 quart of diesel fuel was released to the ground surface during refueling of the direct push drill rig in AOC J. All affected soil was excavated and containerized. Approximately 5 gallons of soil were containerized in a sealed 5-gallon bucket and transported off-site for disposal at Emerald Services, Inc. in Anchorage, AK.

On September 26, 2012, less than 1 quart of hydraulic fluid was released from a hairline crack in the hydraulic filter housing on the direct push drill rig. All affected soil was excavated and containerized. Approximately 5 gallons of soil were containerized in a sealed 5-gallon bucket and transported off-site for disposal at Emerald Services, Inc. in Anchorage, AK.

5. CHEMICAL QUALITY REVIEW

The off-site analytical data were validated for data usability and limitations by the third-party data validators, Kestrel Environmental Technologies, in accordance with the project Uniform Federal Policy for Quality Assurance Project Plans (UFP-QAPP) Work Plan. One hundred percent of these data were validated. The data validation approach is consistent with the UFP-QAPP and the Department of Defense Quality Systems Manual (QSM), Version 4.2 (DoD, 2010), together with the *Contract Laboratory Program National Functional Guidelines for Inorganic Superfund Data Review* (EPA, 2010), *Contract Laboratory Program National Functional Guidelines for Superfund Organic Data Review* (EPA, 2008), and the Technical Memorandum *Environmental Laboratory Data and Quality Assurance Requirements* (ADEC, 2009a).

The cumulative effect of the project non-compliant QC on data usability is measured in terms of the precision, accuracy, representativeness, comparability, completeness and sensitivity (PARCCS). The details of the PARCCS evaluation are presented in the CDQR (Appendix G).

The precision, accuracy, and completeness metric are discussed below.

The data precision metrics are provided in Table 5-1. Precision is measured through a comparison of duplicate sample results and duplicate spike results (i.e., matrix spikes or blank or laboratory control spikes). Approximately 2% of the VOC results were qualified for non-compliant matrix spike/matrix spike duplicate (MS/MSD) RPDs. This level of nonconformance occurrence is not uncommon in the environment analyses of solid samples. Overall, the precision of the project analytical data is deemed to be acceptable.

The accuracy metrics are presented in Table 5-2. Surrogate recoveries outside the acceptance windows were the most frequent QC issue with the analyses. The noncompliant surrogate recoveries are usually indicative of matrix effects that bias the results. Depending on whether the recoveries were higher or lower than the expected value, the results could be biased high (actual concentration may be lower than the reported concentration) or low (actual concentration may be higher than the reported concentration). The data qualifiers include the letters “H” or “L” to alert the data users of the potential bias in the results. Again, the level of noncompliant surrogate recoveries is not out of the ordinary for solid matrices. Occasional problems were also experienced with the MS/MSD recoveries and laboratory control sample recoveries. Overall, the accuracy of the analytical data for the project is deemed acceptable.

Table 5-3 presents the completeness statistics for the off-site sample analyses. Less than 0.1% of the data were deemed not usable and hence, rejected. Practically all of the data are usable as reported and qualified.

Random laboratory blank contamination or trip blank contamination was observed that resulted in qualifying the sample data as non-detected. These are discussed in the CDQR (Appendix G).

As part of data review and validation, the ADEC Laboratory Data Review Checklists, Version 2.7, were completed for each individual laboratory data package and are included in Appendix DV-1 of the CDQR.

6. SUMMARY

Ten AOCs at the Former Fort Morrow were evaluated under this phase of the RI to determine if they met the PALs based on 18 AAC 75, Method 2 soil cleanup levels and the June 2012 EPA RSLs. The ADEC risk calculator was used to determine cumulative risk for each AOC. AOCs H, I, K, and L did meet the PALs for soil and did not have any risk-contributing COPCs in the soil. AOC G had no risk-contributing, or petroleum hydrocarbon, COPCs in the soil and the carcinogenic cumulative risk and health index met acceptance criteria. If specific areas of contamination in AOCs C, D, F, and J were remediated to meet the PALs, the cumulative risk would allow for a closure without restrictions. AOC E met acceptable risk criteria when arsenic detections were removed from the calculations.

Based on the results of the 2012 investigation, each AOC was evaluated and found to fall with one of the following four categories; 1) no further action, 2) petroleum only contamination exceeding PALs, 3) CERCLA hazardous substances exceeding PALs, and 4) or unknown due to the presence of data gaps. The category for each AOC is listed below:

- AOC C – 2 and 4 (uncharacterized buried metal debris),
- AOC D - 2,
- AOC E - 3 and 4 (uncharacterized buried metal debris),
- AOC F - 3 and 4 (uncharacterized buried metal debris),
- AOC G – 1,
- AOC H – 1,
- AOC I – 1,
- AOC J – 3,
- AOC K – 4, and
- AOC L – 1.

The following sections provide a status categorization of each of the 10 AOCs based on the results of the 2012 investigation. A summary of the investigation results from each of the 10 AOCs investigated in 2012 are presented below.

6.1 AOC C

Eighty-three site features were investigated in AOC C. A total of 50 site features were investigated by screening with UVOST technology. A total of 327 UVOST screening boreholes were drilled totaling 5,273 feet drilled with the direct push drill rig. Of the 50 site features, UVOST screening detected possible subsurface fuel signatures at nine site features. Of these nine site features, one was a debris site, two were ground scars, one was a latrine, one was a power house, two were quarters/barracks, and two were storage features. Seven of the 9 possible fuel signatures were below the threshold value of 1%RE exsitu or 1.5% insitu that would represent POL contamination above the PALs. The remaining two site features were C-GS-004 and C-LT-002.

Subsurface contamination was discovered and delineated at C-LT-002. The total amount of contaminated soil was found to be approximately 832 cubic yards.

One site feature (C-XR-001) was screened for radiological contamination with a Ludlum Model 3 gross alpha/beta/gamma meter. No radiological contamination was detected at C-XR-001.

Thirty-nine full suite primary soil samples, 10 fuels only (POL) primary soil samples, and 4 PCB primary soil samples were collected from 39 site features in AOC C for analytical laboratory analysis.

Seven site features had contaminants detected above the project action limits:

- C-DB-001,
- C-LT-002,
- C-PH-001,
- C-PR-001,
- C-ST-003,
- C-ST-006, and
- C-ST-008.

Contaminants detected included 2-methylnaphthalene (18 mg/kg, PAL= 6.1 mg/kg), arsenic (7.2 to 28 mg/kg, PAL= 7.05 mg/kg), bromomethane (0.3 mg/kg, PAL= 0.16 mg/kg), total chromium (370 mg/kg, PAL= 25 mg/kg), and DRO (1,900 to 10,000 mg/kg, PAL= 250 mg/kg). See Appendix A for a listing of detected soil sample analytical results. Appendix B provides a complete listing of laboratory analytical results.

Four groundwater monitoring wells and one piezometer were installed in AOC C. Three of the four monitoring wells were sampled for full suite analysis and filtered metals. DRO (3,500 µg/L, PAL= 1,500 µg/L) and manganese (720 to 750 µg/L, PAL= 320 µg/L) were detected above PALs at one monitoring well (C-MW-001).

A geophysical survey was conducted at three site features in AOC C and buried metal debris was detected at one of the three site features; C-BD-001.

The ADEC risk calculator was used to determine the cumulative risk for each AOC. If the specific areas of petroleum hydrocarbon contamination were remediated to meet the PALs, the cumulative risk would allow for closure without restrictions of AOC C. These specific site features include C-LT-002 and C-ST-008.

A possible exception would be the area of identified buried debris that has not been fully characterized nor delineated (C-DB-001).

6.2 AOC D

Twenty-four site features were investigated in AOC D, and 11 site features were screened with UVOST technology. A total of 103 screening boreholes were drilled with a direct push drill rig totaling 1,385 feet drilled. Of those 11 site features screened with the UVOST, one site feature showed the presence of subsurface contamination; D-TF-002. The total amount of contaminated soil was found to be approximately 256 cubic yards.

Eighty-seven PCB 9-point grid samples were collected from 12 site features at a depth of 6 inches bgs. PCBs were not detected above the PAL (1 mg/kg) at any of the site features in AOC D. Ten primary soil samples were collected for full suite analysis, three samples were collected for POL analysis, and five samples were collected for metals suite analysis. DRO was detected at 21,000 mg/kg (PAL = 250 mg/kg) at D-TF-002. This was the only site feature with contamination above the PALs in AOC D.

One groundwater monitoring well and two piezometers were installed in AOC D. The monitoring well was sampled for full suite analysis and filtered metals. There were no detections above project action limits in groundwater in AOC D. See Appendix A for a listing of detected groundwater sample results. Appendix B provides a complete listing of groundwater sample results.

Two piezometers were installed within the AOC in order to determine the AOC specific groundwater flow direction and gradient through the solution of a standard three-point problem. The two piezometers were installed at site features D-UN-001 and D-DS-001.

One site feature in AOC D was screened with an EM-61 digital metal detector and no subsurface anomalies consistent with significant buried metal were found.

The ADEC risk calculator was used to determine the cumulative risk for each AOC. The cumulative risk was found to be below 10^{-5} with a health index less than 1. Therefore, if the identified area of contamination in AOC D (D-TF-002) was remediated to meet PALs, the cumulative risk would allow for closure without restrictions.

6.3 AOC E

Ten site features were identified for investigation in AOC E. Seven of those features were screened using UVOST technology. A total of 28 screening boreholes were drilled with stainless steel hand augers with a total of 105 feet drilled. The drill rig was unable to access any of the site features due to wet tundra and muskeg, therefore soil material was collected from all of the site features through the use of the hand augers. The soil material collected with the hand augers was screened with the UVOST technology in emulation mode. UVOST screening identified no areas of potential contamination in AOC E.

Seven primary soil samples were collected for full suite analysis and three soil samples were collected for VOC suite analysis. MTBE, methylene chloride, and arsenic were detected above project action limits in three site features E-DS-004, E-DS-005, and E-OT-001. MTBE concentrations ranged from 3.2 to 3.9 mg/kg (PAL= 1.3 mg/kg), the arsenic concentration was 7.2 mg/kg (PAL= 7.05 mg/kg), and methylene chloride concentrations ranged from 0.31 to 0.41 mg/kg (PAL= 0.016 mg/kg). Methylene chloride is thought to be a laboratory contaminant.

No groundwater monitoring wells were installed during the 2012 field season. There were several pre-existing groundwater monitoring wells in AOC E, and one was selected near site feature E-DS-001 for groundwater sampling. It was sampled for full suite and filtered metals analysis. There were no detections in groundwater above project action limits in AOC E.

Three site features were screened with EM-31 and EM-61 digital metal detectors to determine the presence of buried metal. One site feature, E-DS-001, was found to have significant anomalies that were interpreted to be associated with buried metal or metallic debris. Therefore, this site feature was not screened nor sampled.

The ADEC risk calculator was used to determine the cumulative risk for each AOC. When arsenic (the sole contributor to the ILCR) was removed from the calculation, the cumulative risk in AOC E was found to meet the 10^{-5} criteria with a health index less than 1. Therefore, the cumulative risk allows for closure without restrictions. A possible exception to this is the identified area of buried debris (E-DS-001) that have not been fully characterized nor spatially delineated.

6.4 AOC F

Sixteen site features were investigated in AOC F. Twelve of the site features were screened with UVOST technology. A total of 78 boreholes were drilled totaling 671 feet. Of those 12 site features screening with the UVOST, two showed the presence of possible subsurface POL contamination.

Ten full suite primary soil samples and one POL suite soil sample were collected from nine site features in AOC F. Two site features were found to have detected contamination above project action limits: F-OT-001 and F-OT-003. These detected contaminants include DRO (5,400 mg/kg, PAL= 250 mg/kg) and MTBE (1.6 mg/kg, PAL= 1.3 mg/kg). The total amount of contaminated soil was found to be approximately 43 cubic yards.

One groundwater monitoring well was installed in AOC F and was sampled for the full suite of analytes and a filtered sample was also collected for metals analysis. There was a single detection of manganese above the project action limit in both the unfiltered and filtered metal samples.

Two site features were surveyed with a high resolution metal detector to determine the presence of buried metal. One site feature, F-DS-001, was found to have anomalies associated with buried metal.

The ADEC risk calculator was used to determine the cumulative risk for each AOC. The cumulative risk in AOC F was found to be below 10^{-5} with a health index less than 1. Therefore, if specific areas were remediated to meet PALs, the cumulative risk allows for closure without restrictions. A possible exception to this would be the identified area of buried debris (F-DS-001) that has not been fully characterized.

6.5 AOC G

One site feature was screened and sampled in AOC G, G-OT-001. A total of four boreholes were drilled with a stainless steel hand auger, totaling 14 feet. No screening boreholes showed the presence of potential subsurface contamination.

One soil sample was collected for full suite analysis and showed methylene chloride contamination present at a concentration above the project action limit (0.022 mg/kg, PAL= 0.016 mg/kg). This contaminant is believed to be a result of laboratory contamination.

No groundwater monitoring wells were installed and no groundwater samples were collected in AOC G.

No geophysical surveys were conducted in AOC G.

The ADEC risk calculator was used to determine a cumulative risk for each AOC. There were no risk-contributing or petroleum hydrocarbon COPCs in AOC G. Therefore, the cumulative risk would allow for closure without restriction of AOC G.

6.6 AOC H

Twenty-five site features were screened with UVOST technology. A total of 111 screening boreholes were drilled, totaling 1,434 feet. No potential subsurface contamination was detected with the UVOST at any of the 25 site features screened.

Twenty-five primary soil samples were collected for full suite analysis and three soil samples were collected for VOC suite analysis. Samples collected at two site features had MTBE detections above the project action limit. The range of MTBE concentrations was 1.8 to 7.7 mg/kg (PAL= 1.3 mg/kg). MTBE was not used in fuel during the occupation of the site by the U.S Army during 1942 and 1943. MTBE has a relatively higher water solubility and persistence than other components of gasoline which can cause it to travel faster and farther than many of the other gasoline components. The presence of MTBE may be indicative of a non-Fort Morrow recent release of gasoline.

One groundwater monitoring well was installed in AOC H and was sampled for the full analytical suite. A second filtered groundwater sample was collected for metal analysis only. There were no detects in groundwater above project action limits in AOC H.

No geophysical surveys were conducted within AOC H.

The ADEC risk calculator was used to determine a cumulative risk for each AOC. There were no risk-contributing or petroleum hydrocarbon COPCs in AOC H. Therefore, the cumulative risk would allow for closure without restriction of AOC H.

6.7 AOC I

Five site features were investigated in AOC I. Three site features were screened with UVOST technology. A total of 52 screening boreholes were drilled, totaling 948 feet. Of those three site features screened with the UVOST, one showed the presence of possible subsurface contamination.

Three soil samples were collected for full suite analysis and four soil samples were collected for POL analyses from three site features. One site feature, I-QT-001, had methylene chloride, a likely laboratory contaminant, detected above the project action limit at a concentration of 0.13 mg/kg (PAL= 0.016 mg/kg).

Two groundwater monitoring wells were installed in AOC I. Both groundwater monitoring wells were sampled for full suite analysis and filtered metals. There were no detections in groundwater above project action limits in AOC I.

No geophysical surveys were conducted within AOC I.

The ADEC risk calculator was used to determine a cumulative risk for each AOC. There were no risk-contributing or petroleum hydrocarbon COPCs in AOC I. Therefore, the cumulative risk would allow for the closure without restriction of AOC I.

6.8 AOC J

A total of 68 site features were identified for investigation in AOC J. Thirty-two site features were screened by the UVOST. A total of 364 boreholes were drilled, totaling 5,592 feet. Of the 32 site features screened, the UVOST detected potential subsurface contamination at four site features: two spill sites (J-SP-002 and J-SP-003) and two warehouses (J-WH-002 and J-WH-003).

Modeling with the ArcGIS software indicates that approximately 177 cubic yards of soil is contaminated above PALs at site feature J-SP-003, 2 cubic yards at site feature J-SP-002, and 131 cubic yards at site feature J-WH-002.

Twenty-six site features were sampled; 28 soil samples were collected for full suite analysis, 16 soil samples were collected for POL suite analysis, nine soil samples were collected for PCB analysis and one soil sample for metals analysis. Four site features had contaminants detected above the PALs: J PR-001, J-SP-002, J-SP-003, and J-WH-002. Contaminants detected above project action limits include DRO (1,500 to 12,000 mg/kg, PAL= 250 mg/kg), RRO (12,000 to 14,000 mg/kg, PAL= 10,000 mg/kg), arsenic (14 mg/kg, PAL= 7.05 mg/kg), and lead (4,300 mg/kg, PAL= 400 mg/kg).

Four groundwater monitoring wells and three piezometers were installed in AOC J. Four groundwater samples were collected; one from each well for full suite analysis and filtered metals. Monitoring wells J-MW-002 and J-MW-003 had detections of cobalt (6.7 to 12 µg/L, PAL= 4.7 µg/L), arsenic (11 µg/L, PAL= 10 µg/L), iron (18,000 to 46,000 µg/L, PAL= 11,000 µg/L), lead (24 µg/L, PAL= 15 µg/L), and manganese (370 to 420 µg/L, PAL= 320 µg/L) above the PALs.

No geophysical surveys were conducted within AOC J.

The ADEC risk calculator was used to determine the cumulative risk for each AOC. The cancer risk exceeds 10^{-5} due to arsenic. If arsenic is removed from the calculation, then the cumulative risk would be acceptable and would meet the 10^{-5} criteria. In addition the petroleum fractions, DRO and RRO were detected in most of the samples and they would need to be addressed with respect to the PALs, along with one exceedance of lead in soil.

6.9 AOC K

Thirty-four site features were screened with UVOST technology in AOC K. A total of 182 screening boreholes were drilled, totaling 3,094 feet. Of those 34 site features screened, one site feature showed the presence of possible subsurface contamination that may require additional characterization.

Twenty-three soil samples were collected for full suite analysis, one soil sample was collected for POL analysis, and three soil samples were collected for PCB analysis from 23 site features in AOC K. There were no detections above PALs in AOC K.

Three groundwater monitoring wells and two piezometers were installed in AOC K. All three monitoring wells were sampled for full suite analysis and for filtered metals. There were no detections above PALs in groundwater in AOC K.

A geophysics survey was not conducted in AOC K.

The ADEC risk calculator was used to determine a cumulative risk for each AOC. There were no risk-contributing or petroleum hydrocarbon COPCs in AOC K. Therefore, the cumulative risk would allow for closure without restrictions of AOC K.

6.10 AOC L

Twelve site features were screened with UVOST technology in AOC L. A total of 115 screening boreholes were drilled, totaling 1,854 feet. Screening by the UVOST did not indicate the presence of subsurface contamination at any of the site features.

Six soil samples were collected for full suite analysis and one soil sample was collected for POL suite analysis from six site features. There were no contaminants detected above PALs in AOC L.

Two groundwater monitoring wells and four piezometers were installed in AOC L. Groundwater samples were collected for both full suite analysis and metals only analysis from both groundwater monitoring wells. There were no detections above project action limits in groundwater in AOC L.

A geophysical survey was not conducted in AOC L.

The ADEC risk calculator was used to determine a cumulative risk for each AOC. There were no risk-contributing, or petroleum hydrocarbon COPCs in AOC L soil. Therefore, the cumulative risk would allow for closure without restriction of AOC L.

6.11 Data Gaps

Potential data gaps associated with each AOC are identified below.

6.11.1 AOC C

- The composition and extent of buried metallic debris at site feature C-BD-001 is unknown.
- The possible POL contamination observed directly below the suspected sewage discharge pipe at site feature C-GS-004 is undefined.
- A groundwater sample for EDB analysis should be collected from groundwater monitoring well C-MW-001.
- The extent of underground piping and tanks at C-LT-002.

6.11.2 AOC D

No data gaps were identified.

6.11.3 AOC E

- The composition and lateral extent of buried metallic debris at site feature E-DS-001 is not clearly defined.

6.11.4 AOC F

- The composition and extent of buried metallic debris at site feature F-DS-001 is unknown.
- The possible POL contamination observed at site feature F-BU-001 has not been sampled.
- The contamination found at site feature F-OT-001 may not be adequately bounded to the southeast.

6.11.5 AOC G

No data gaps were identified.

6.11.6 AOC H

No data gaps were identified.

6.11.7 AOC I

No data gaps were identified.

6.11.8 AOC J

No data gaps were identified.

6.11.9 AOC K

The maximum concentration of DRO contamination identified at site feature K-ST-001 is not accurately known and may require further characterization. The extent of DRO contamination at this site feature has been delineated by field screening.

6.11.10 AOC L

No data gaps were identified.

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